Khokana

the vernacular village and its mustard-oil seed industrial heritage

Khokana, the vernacular village and its mustard-oil seed industrial heritage

Survey Report

March 2020

Survey Report

March 2020

Japan Center for International Cooperation in Conservation,
Tokyo National Research Institute for Cultural Properties

2019 Networking Core Centers for International Cooperation in the Conservation of Cultural Heritage Project
"Technical Assistance for the Protection of Damaged Cultural Heritage in Nepal"
commissioned by Agency for Cultural Affairs, Government of Japan

Networking Core Centers for International Cooperation in the Conservation of Cultural Heritage Project

"Technical Assistance for the Protection of Damaged Cultural Heritage in Nepal"

Khokana

the vernacular village and its mustard-oil seed industrial heritage

Survey Report

Tokyo National Research Institute for Cultural Properties

2019 Networking Core Centers for International Cooperation in the Conservation of Cultural Heritage Project
"Technical Assistance for the Protection of Damaged Cultural Heritage in Nepal"

Khokana, the vernacular village and its mustard-oil seed industrial heritage

Survey Report

Published in March 2020

Address: 13-43, Ueno-Koen, Taito-ku, Tokyo, 1108713

Preface

On 25th April 2015, a 7.8 magnitude earthquake caused enormous damage to a large area of Nepal. The damage directly affected world heritage sites including Kathmandu Valley and historic settlements featuring unique traditional Newar houses. Rehabilitation of settlements where people conduct their daily lives is complicated by the need to preserve them as cultural heritage sites.

This report contains survey results from Khokana, which is registered in the tentative list of world heritage sites. This survey was carried out from September 2015 to December 2019 by a team from the Urban Design Laboratory of The University of Tokyo and Kobe Design University. We worked collaboratively with experts in the conservation of cultural heritage sites from The University of Tokyo, Kagawa University, Tohoku University, Sapporo City University, and Tokyo National Research Institute for Cultural Properties. Team members collectively offered comprehensive viewpoints on urban design, conservation and preservation, building structure, and intangible cultural heritage.

Special thanks are given to Mr.Rabindra Maharjan, Mr.Buddhi Ratna Dangol, Mr. Nabin Dangol, Mr.Omkar Maharjan and People in Khokana for their understandings and kind support. We would like to acknowledge the support of Dr. Bijaya K. Shrestha, Mr. Ram Shrestha, Mr. Milan Bagale, Ms.Renu Maharjan and Dr.Shovana Bajracharya during our survey in Khokana.

Today, five years after the great earthquake, we would like to share the survey results with other settlements in Kathmandu Valley with similar features to Khokana. We hope this report will prove helpful in determining desirable conservation methods and rehabilitation from these natural disasters.

NISHIMURA Yukio

Professor, Kobe Design University
Head, Japanese Experts Team in conservation of Historic Settlements

Legend

This report presents survey projects in Khokana, Nepal, from 2015 to 2019. The scope of the survey is as follows: (1) Basic information of Khokana, (2) Urban structure, (3) Town houses, and (4) Damage condition of houses after the earthquake. Based on the results, a plan for conservation in Khokana is proposed in chapter 5.

Please note that a portion of this report is reproduced from the 2016 survey; these sections will need to be updated.

The project was financially supported by the Agency for Cultural Affairs, Government of Japan under the project called 'Project for International Contribution to Cultural Heritage Protection "Project for Investigation of Damage Situation of Cultural Heritage in Nepal" in 2015, and 'Networking Core Centers for International Cooperation in the Conservation of Cultural Heritage Project "Technical Assistance for the Protection of Damaged Cultural Heritage in Nepal" from 2016 to 2019.

Contents

Editorial supervisors

NISHIMURA Yukio (Professor, Kobe Design University)

TOMODA Masahiko (Director, Japan Centre for International Cooperation in Conservation (JCICC), Tokyo National Research Institute for Cultural Properties (TNRICP))

KANAI Ken (Head, Conservation Design Section, JCICC, TNRICP)

Editor

MORI Tomoko (Associate Professor, School of Design, Sapporo City University)

ASADA Natsumi (Associate Fellow, JCICC, TNRICP)

Authors

Chapter 1 MORI Tomoko

Chapter 2 Section 1 MORI Tomoko
Section 2 MORI Tomoko
Section 3 ISHIMURA Tomo (Head, Audio-Visual Documentation Section, Department of Intangible Cultural Heritage, TNRICP)
Section 4 SAMMONJI Masaya (Former postgraduate student, The University of Tokyo)
Section 5 KUROSE Takefumi (Associate Professor, Department of architecture and urban design, Kyushu University)
Section 6 YAMADA Hiroki (Visiting Researcher, JCICC, TNRICP / Researcher, Urban Design Institute Co., Ltd)
FURUKAWA Naoaki (Research Assistant Professor, Faculity of urban environmental sciences, Tokyo Metropolitan University)
Section 7 SAMMONJI Masaya

Chapter 3 Section 1 Tomoko Mori
KOBAYASHI Risa (Former postgraduate student, The University of Tokyo)
MIYAMOTO Mitsuhiro (Associate Professor, Faculty of Engineering, Kagawa University)
Section 2 HAMADA Megumi (Former postgraduate student, The University of Tokyo)

Chapter 4 Section 1 MORI Tomoko
Section 2 YAMADA Hiroki
MIYAMOTO Mitsuhiro
Section 3 KUROSE Takefumi
TAKEUCHI Yasushi (Professor, Faculty of Engineering, Tohoku Institute of Technology)
Section 4 MORI Tomoko

Chapter 5 Kathmandu project team, Urban Design Laboratory (KAWATA Sakura, SUNAZUKA Taiga, KOBAYASHI Risa, SAMMONJI Masaya, HAMADA Megumi, former postgraduate students, and faculty members), The University of Tokyo

Chapter 6 MORI Tomoko

1. Introduction

Fig. 1-1-1 Area map of Khokana village (From Bing map , modified by the author)

Fig. 1-1-2 The southern settlement area of Khokana village (From Bing map, modified by the author)

Fig. 1-1-3 Aerial photo in 1973 (Gutschow Neils: Architecture of the Newars. A history of building typologies and detils in Nepal, documentation drawings by Bijay Basukala, vol.1, the early periods, Serindia Publications, 2011)

1. Introduction

1.1. Outline of Project

The earthquake occurred on 25 April 2015 in Nepal (hereafter referred to as 'Gorkha Earthquake') and its aftershocks directly affected many of the heritage assets not only the monuments including ancient royal palaces and temples but also the private traditional houses, which constitute historic townscape.

The healthy recovery of the whole Nepal is of course hoped for, but the rehabilitation of the historic settlements, where inhabitants are leading everyday life, is strongly needed. All damaged settlements faced difficulties of securing the safe living environment for inhabitants during rehabilitation while developing sustainable communities by keeping historical and cultural values of their townscapes and spatial organisations.

The project, titled 'Technical Assistance for the Protection of Damaged Cultural Heritage in Nepal', was commissioned by Agency for Cultural Affairs of the Japanese government as part of 'Networking Core Centers for International Cooperation in the Conservation of Cultural Heritage Project' with Tokyo National Research Institute for Cultural Properties as the implementation body.

The main purpose of this project is to provide both technical information and actual support work for the rehabilitation of the damaged cultural heritage undertaken by the local authorities or communities.

As a pilot case study on the rehabilitation of damaged historic settlements, the continuous survey on the historic settlement of Khokana was conducted by Japanese experts team in conservation of historic settlements, mainly the Urban Design Laboratory of The University of Tokyo. The survey aimed to 1) clarify the present situation of rehabilitation and preservation and 2) examine design guideline on façades of buildings for rebuilding and renovation. A field survey and interviews, as development processes of drafting a plan for the preservation and rehabilitation of historic settlements, were carried out in collaboration with local experts and inhabitants for the purpose of transferring technical knowledge. Along with the clarification of issues for the realisation of preservation and rehabilitation of townscape reflecting the current condition of each settlement, through the development of plans for the Khokana settlement, issues on the institutional design were examined.

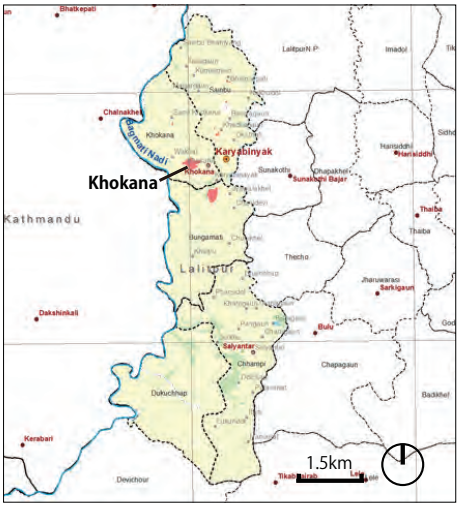


Fig. 1-2-1 Administrative district of Karya Binayak city[1]

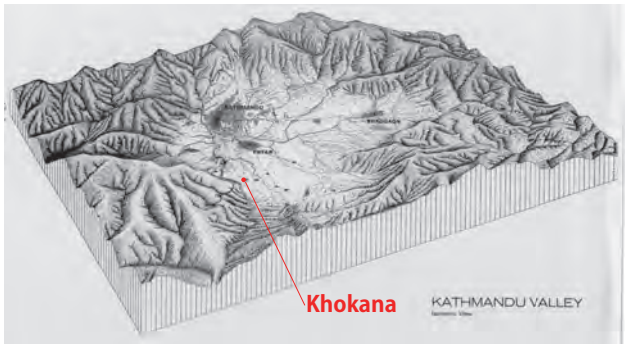


Fig. 1-2-2 Isometric figure of the Kathmandu valley Quoted from Kathmandu valley[2]

1.2. Outline of Khokana

(1) Location and administrative districts

Khokana Village is located in the southwestern area of the Kathmandu Valley, approximately six kilometres south of the ancient capital of Patan, in the municipality of Karya Binayak. It is found among the hillocks squeezed between the Bagmati and Nakkhu Rivers. The ridge running from north to south is called Ekantakuna-Tikabhairab Road and Khokana Village covers the area of graded land to the west. As the region's main road, roadside development is being advanced along Ekantakuna-Tikabharaid Road (Fig. 1-1-1).

The municipality of Karya Binayak was newly formed from five Village Development Committees (VDC) in 2014. The Khokana VDC was reorganised into Districts 6, 7, 8 and 9 of the municipality of Karya Binayak and now continues as an administrative district (Fig. 1-2-1).

Khokana Village, which is located in the southwest area of the Kathmandu Valley, previously lay along a former trade route between India and Tibet that flourished during the medieval period and was located in an area through which there was a regular flow of people (Fig. 1-2-2).

(2) Topographical and geographical features

In Nepal, where the topography differs greatly from the north to the south, it can be observed from past research[3] classifying Nepalese village settlement patterns and vegetation that the Kathmandu Valley is in the 'MAN- MADE TREELESS Zone' (Fig. 1-2-3), and its settlement pattern is 'Clustered, dispersed, or compact' (Fig. 1-2-4). Therefore, Khokana Village may be classified as a Nepalese village settlement.

(3) Population

Based on the 2011 national census, the population of Khokana Village is 4,927[4]. Compared with the 2,546[5] people recorded in sources from 1969, the population has roughly doubled in the last forty years. Furthermore, data from the time of the 2015 Gorkha earthquake showed the population to be 5,386[6]; thus, it may be understood that there has been a trend towards population increase in recent years. We were not able to obtain detailed information by age group.

Ninety-seven percent of residents are Newari who engage in agriculture and are called 'Jyapu'; there are many whose family name is Dangol or Maharjan[7].

(4) Overview of damage from the April 2015 earthquake and recovery efforts

In Khokana, nine people were killed and twenty-eight wounded (Source: note 6) by the 2015 Gorkha earthquake, which also caused extensive damage to traditional buildings that will be detailed later.

After the earthquake, the Khokana Reconstruction and Rehabilitation Committee (hereafter 'the Committee') comprising politicians, people with academic experience, local NGOs, and others was formed in the village. The Committee is an action organisation promoting self-governing recovery efforts, such as removing rubble and cleaning up, dismantling crumbled buildings, and also writing the proposed future recovery plan[8]. At the time of a November 2015 survey regarding, in part, conditions within the village, the public spaces had been cleaned and several buildings that had been either completely or partially destroyed had been taken down; however, in popularly inhabited areas, the removal of rubble and reconstruction projects have still not yet advanced. Amongst the residents affected by the earthquake, there are people living dual lives, sleeping in temporary residences around the outskirts of the village and returning to their partially destroyed homes during the day.

Fig. 1-2-3 Vegetation classification by geographical features Quoted from 4 villages: Architecture in Nepal

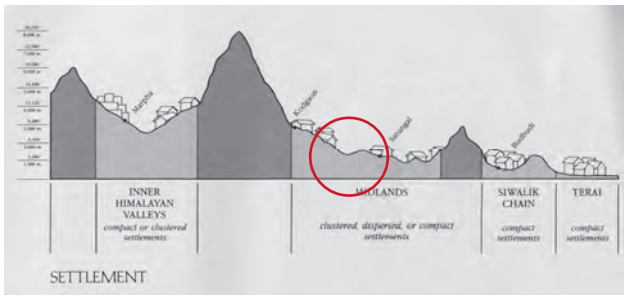


Fig. 1-2-4 Settlement from classification Quoted from 4 villages: Architecture in Nepal

1.3. Khokana as an Item on World Heritage Tentative List

(1) World Heritage Site Kathmandu Valley and items on the Tentative List

Nepal ratified the World Heritage Convention in 1978; the Kathmandu Valley was inscribed on the list of World Heritage Sites the following year. At the present time as at date of report, Nepal has two natural heritage and two cultural heritage sites listed as World Heritage sites and fifteen further sites on the tentative list.

The Kathmandu Valley, which has a total of seven World Heritage properties, including three royal palaces and four religious facilities, became Nepal's first World Heritage site in 1979. Moreover, in the valley, the following four properties are also on the tentative list[9] (Fig. 1-3-1):

-The early medieval architectural complex of Panauti (1996)

-Khokana, the vernacular village and its mustard-oil seed industrial heritage (1996)

-Vajrayogini and early settlement of sankhu (2008)

-Medieval Settlement of Kirtipur (2008)

(2) Khokana Village listed on the Tentative List

Khokana Village was listed on the World Heritage Tentative List in 1996 as "Khokana, the Vernacular Village and its Mustard-Oil Seed Industrial Heritage." [11]

Criteria: (i)(iii)(iv)(v)

Description: Khokana is a unique village which can be taken as a model of a medieval settlement pattern with a system of drainage and chowks. It houses chaityas and a Mother Goddess temple. The mustard-oil seed industry has become the living heritage of the village.

Given the fact that this listing occurred during a comparatively early stage, it cannot be said that registration standards and evaluation of value were carried out sufficiently, but it was positively evaluated for (1)being a representative village formed during the medieval period, (2)being a village having religious temples, and (3) its traditional method of mustard-oil squeezing that is unique to this land.

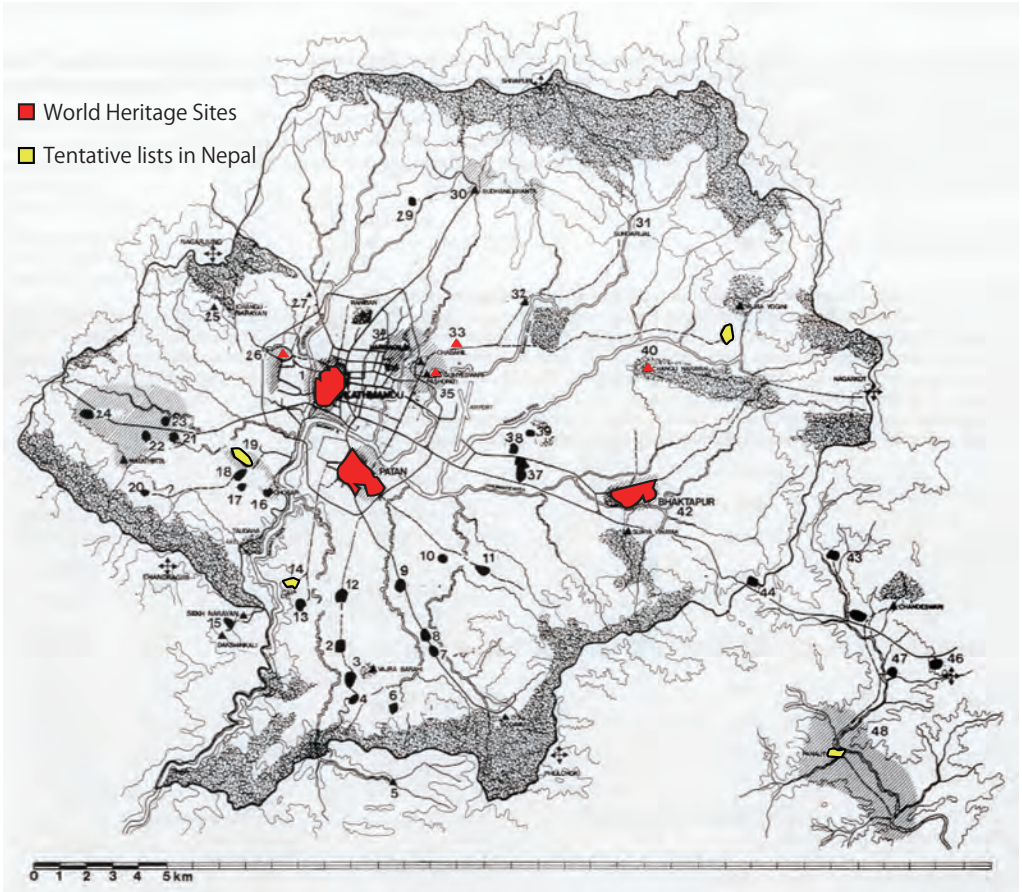


Fig. 1-3-1 Properties of World Heritage Site of Kathmandu Valley, and on the Tentative List (Modified from the map based on Newar Towns and Buildings[10] ; Khokana village is located at No.14 in the map.

(3) Nepalese legislation concerning Cultural Heritage Protection

Cultural Heritage preservation in Nepal is managed by the Department of Archaeology under the Ministry of Culture, Tourism and Civil Aviation pursuant to the Ancient Monument Preservation Act, 2013. Considering the tangible cultural heritage related to this research, temples, commemorative buildings and popular residences that have a history of 100 years or longer are defined as 'Ancient Monuments' and places where the 'Ancient Monuments' are situated are defined as 'Preserved Monument Areas.' The properties that comprise the Kathmandu Valley World Heritage Site are protected by these mechanisms.

However, the historical settlements registered in the Tentative List are not covered by the above protections. Ironically, the damage caused to this medieval settlement landscape by the recent earthquake has become the impetus for Nepal's cultural administration to define these medieval settlement landscapes for the first time as "Historical Settlements" and to establish guidelines for their recovery[12].

Notes:

1. http://lgcdp.gov.np/phase1/home/map_newmunicipality.php (accessed 2016-02-21)
2. Carl Pruscha, et al.: Kathmandu Valley vol.1, Anton schroll & Co.,1975
3. Katherine D.Blair: 4 villages: Architecture in NEPAL,Craft & Folk Art Museum, 1983
4. Government of Nepal :National Population and Housing Census 2011 (Village Development Committee/Municipality), p.40, 2012
5. Government of Nepal :The physical development plan for the Kathmandu Valley, p.64, 1969
6. Source Email correspondent (Nabin Dagol) (2015-10-02) See data on the population and victims in Khokana vilalge
7. Shovana Bajracharya et al.: KOKANA NI KURASU (Living in Khokana) only in Japanese, P26, Mukudori Shobou, 2008, 11
8. We got Khokana proposal 3rd draft from Nabin Dangol 2015-10-02
9. http://whc.unesco.org/en/statesparties/np (accessed 2016-02-03)
10. Niels Gutschow: Newar Towns and Buildings, VGH Wissenschaftsverlag , 1987
11. http://whc.unesco.org/en/tentativelists/844/ accessed 2016-02-03)
12. "Conservation Guidelines for Post-2015 Earthquake Rehabilitation" currently being prepared by UNESCO Office in Kathmandu Domestic Consultant Kai Weise. However, we have learned that these guidelines were a seminar invited by the Archaeological Bureau and the UNESCO Office in Kathmandu, and have not yet been made the official guidelines of the Nepal government.

2. Structure of Settlement

2. Structure of Settlement

2.1. Spatial Analysis of Region

(1) Territory and two settlements

The territory of Khokana Village roughly overlaps with the territory of the former Khokana VDC. Its boundaries are fundamentally water boundaries; it is divided from the surrounding region by the Bagmati River to the west, an irrigation canal to the east, and a mountain stream to the south. Because it escapes the erosion from the roadside housing development along the main ridge road (Ekantakuna-Tikabhairab Road), Khokana Village's residents continue their historical way of life and use of the land. The village settlement is divided into the two areas of north and south. The south comprises the former Districts 1-8 (hereafter, 'the Southern Settlement Area'). while the north is the former District 9 (hereafter 'the Northern Settlement Area')[1], with populations of 5,132 and 236 respectively[2]. Over 90% of Khokana's residents live in the Southern Settlement Area, which has a dominant presence.

(2) Cultural landscape

The majority of Khokana residents belong to the farming caste and make their living through farming. The two settlement regions are set among hillocks and the topography gently inclines in a cone shape towards the Bagmati River, with terraced paddy fields forming a beautiful landscape. The highly douse settlement is built on, which are disadvantageous for a water environment; they buit highly dense settlement and the conic topography is used almost entirely as farmland (Fig. 2-1-1). Double-cropping is practiced there for rice planting and wheat, potatoes, and brown mustard. The 1977 survey report calls the terraced paddy field landscape that spreads from the Southern Settlement Region to the north the 'amphitheater', recording that it is an important element of the Kathmandu Valley cultural tourism[3]. These terraced paddy fields of Khokana Village are a cultural landscape defined as a 'combined work of nature and

Fig. 2-1-1 Cultural landscape of Khokana village (Taken by author on 5 Dec. 2015)

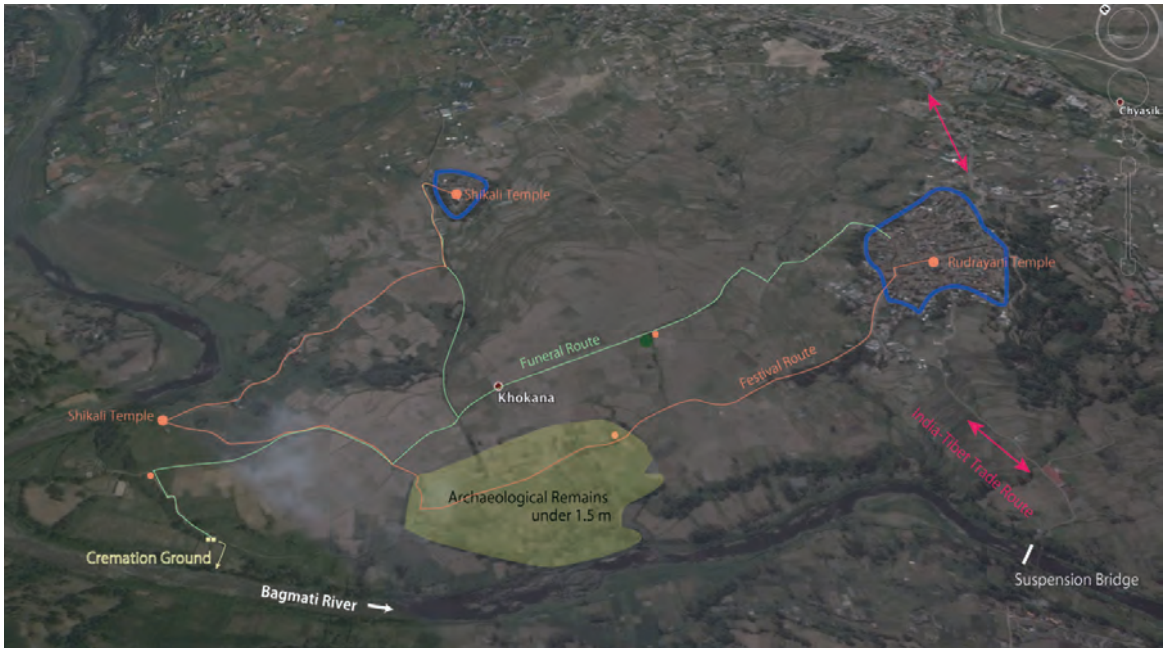


Fig. 2-1-2 Territory of Khokana village main temples main route etc. (From Google Earth modified by the author)

man'[4].

Furthermore, the temple at the centre of the settlement and the Shikari temple on its western edge are important ritual spaces, and rituals are traditionally performed along a fixed route from the settlement. There is a crematorium on the Bagmati riverside and ashes are released into the river after cremation. The route for funerals is well-established, and particularly in the South Settlement Area, which has three entrances, the routes and entrances are divided into outward and return journeys. In the northwest, there exist burial remains that are thought to be the ruins of a village. The artefacts in the ground make it unsuitable as cultivated land, so it remains wilderness; however, there are stone places of worship and stone statues interspersed across the land, so it is an important religious space. It has already been noted that Khokana Village lay on the medieval Indian-Tibetan trade route; it is also believed that this route ascended from India to the Bagmati River, entered the Southern Settlement Area, passed along the ridge road, and headed towards Patan (Fig. 2-1-2). At present, several houses have been established on the new residential land along the farm road, and a steel tower runs across the terraced paddy fields. This terraced paddy field landscape, which was once called an 'amphitheater', is undergoing a process of unfortunate changes.

(3) Water source (Rajkulo)

The water source for the village's paddy fields lies approximately eight kilometres south of the village and is said to be a tributary of the Rajkulo (meaning 'King's canal') built by the Malla Kings during the medieval period[5], but we have not conducted a detailed investigation during this research period.

The Rajkulo is an irrigation system supplying water to watering places and ponds of the three royal palaces of Kathmandu, irrigating water between them; it existed as an irrigation canal circulating water throughout the Kathmandu Valley. However, there are no records of who commissioned the construction of the Rajkulo; with few sources existing following rapid urbanisation, the whole story has not been made clear[6].

Fig. 2-1-3[7] illustrates the Rajkulo route to the Patan palace. While it is limited to the periphery of the city, part of the Rajkulo still exists and, with the support of the Indian government, an NGO[8] had carried out the first stage of a restoration project by 2009, reconstructing it as far as Teku, five kilometres from the royal palace. When it is completed, it will be possible to supply water to 40,000 people and 450 hectares of farm land. However, the article detailing these figures also records that the project is at an impasse due to insufficient funding, though we have not been able to confirm the latest developments regarding this project.

Further understanding and reconstructing the Rajkulo is not only a measure to solve the urban sector issues of Kathmandu, which suffers from water shortages, but should also be re-evaluated culturally as an important system supporting the prosperity and life culture of the Kathmandu Valley. We wish to make collecting information about the Rajkulo and the understanding of its current state an issue for the future.

(4) Irrigation system

Regarding water derived from a water source, we surveyed the irrigation system in Khokana Village[9]. The majority of the main canal, which is called a tributary of the Rajkulo, is maintained as a concrete canal and exists as a boundary of the Khokana Village territory. At present, large-scale residential land development is progressing on the graded land from above this main canal to the mountain ridge road. As the water environment of the land at the top of the irrigation canal, just outside the territory of Khokana Village, is disadvantageous for farm land, it was inevitable that it would be converted into residential land following urbanisation. The main canal supplies water through the tributary, which has been skilfully designed to use the natural slope of the conic topography toward the river and the natural depression of the land to reach the terraced paddy fields spread below. Towards the terraced paddy fields

Fig. 2-1-3 Rajkulo to the Patan palace (Quoted from Nepali Times , modified by the author)

lying even further to the north of the slightly elevated Northern Settlement Area, the canal bifurcates and distributes water to each settlement area. The tip of the ridge (① in Fig. 2-1-4) has the function of a water intake facility. When watering the fields before rice planting, the water gate is first opened for four days and nights and water running through the main canal accumulates here. When water volume reaches capacity, it is released all at once, managed by the village residents. Biannually, before and after rice planting, the sections to be managed by the Northern and Southern Settlement Areas are decided, bottom dredging is conducted collaboratively for one week.

The two residential settlements on elevated ground also draw in water bifurcated by the main canal, which flows through the reservoir. In the Southern Settlement Area, sophisticated knowledge and technology is employed to use the elevation differences within the settlement areas, construct reservoirs at key points to distribute water throughout the settlement through culverts, and establish canals around the perimeter of the settlement area to release water into the terraced paddy fields spread below.

It is clear from the above that, similar to the Rajkulo irrigation system in the Kathmandu Valley, there is also a sophisticated irrigation system inside the territory of the village.

Notes:

1. See 1.1.
2. Source Email correspondent (Nabin Dangol) (2015-10-02) See data on earthquake dead for April 25 2015
3. UNESCO, UNDP: Master plan for the conservation of the cultural heritage in the Kathmandu Valley, 1977.3
4. UNESCO, World Heritage Center: The Operational Guidelines for the Implementation of the World Heritage Convention, 2008
5. Source Email Correspondent (Nabin Dangol) We received the “Khokana proposal 3rd draft” (2015-10-02)
6. Kapil Bright: Renovating Kathmandu’s ancient canals, ECS Nepal, 2011.7
7. Mallika Aryal: Reviving Patan’s rovyal canal, Nepali Times, No. 273, 2005.11
8. Environment and Heritage Conservation Nepal (EHCN)
9. On December 5, 2015, we conducted an onsite survey with the help of three guides Nabin Dangol, Jeevan Dangol and Buddhi K. Dangol from the village and also conducted a hearing survey.

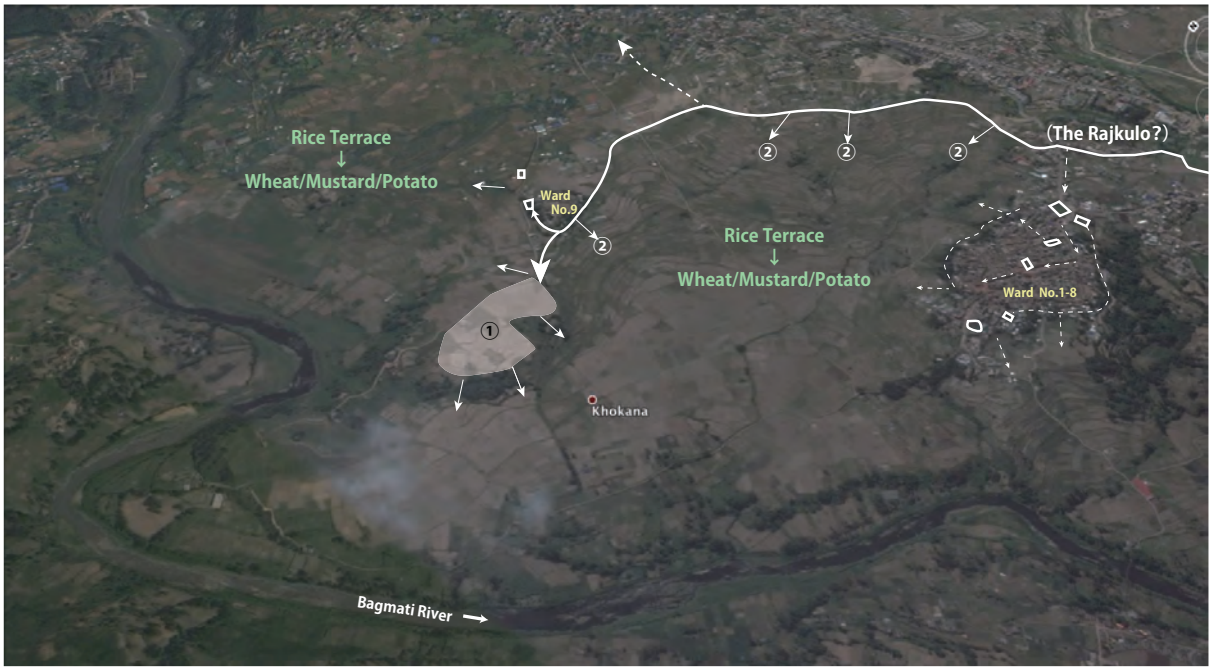


Fig. 2-1-4 Territory of Khokana village : Irrigation system (From Google Earth, modified by the author)

2.2. Settlement Area

(1) Overview of the southern settlement area

As detailed above, the Southern Settlement Area is the centre of Khokana Village. To the east, Khokana Road is a branch road of the Ekantakuna-Tikabharaib Road and as a main connecting road to the village, it is kept in good repair. The bus towards Kathmandu City stops on Khokana Road, and the road heading southeast continues on to Bungamati Village. The west side of the settlement lies on a trade route headed towards the Bagmati River. Along the river, there are suspension bridges for pedestrians, but it is impossible for automobiles to cross. Inside the settlement area, there are sizable vehicles, but they are few in number, with many motorbikes moving unpredictably around the streets.

In the settlement area, the remains of three gates (Dhoka) serve as entrances. At present, the dhoka near the bus stop towards the east is the main entrance to Khokana; sited there is a restaurant establishment on the first floor of a modern building, and the area is crowded with people coming and going. The north dhoka connects to the route for funerals and the west dhoka leads into the route for ritual processions.

The Rudrayanee (Rudrayani) Temple soars above the centre of the settlement area. An example of Nepalese architecture, it is a three-story Hindu temple that forms a central ritual space of the village, together with the adjacent pagoda, pond, watering place (Hiti) and rest place (Pati), and the Kwoe Lachhi Chowk down towards the west. The street running east to west is the central axis joining these two points. In comparative terms, there are many traditional Newar-

Fig. 2-2-1 Streets and its width in the southern settlement area


Fig. 2-2-2 Main street that connects Rudrayanee Temple and Kwoe Lachhi Chowk


Fig. 2-2-3 Photo from the infront of Rudrayanee Temple

style dwellings nearby that, together with the Rudrayanee Temple, convey the visage of the medieval period. However, intermittently, one can see the modernisation in building styles and overbuilding.

(2) Roads

The Table in Fig. 2-2-1 indicate the actual measurements of the road width. That the east-west axis (hereafter, the Main street) is the main street in the settlement area can be seen from its width. The main roads (marked red on the map) are all connected inside the settlement area, and the three entrances are located on branch roads breaking off in a key shape from the Main street. Alongside the roads paved with brick and stone, connected houses form the townscape. The boundary between the public space of the roads and private land is clearly marked by the pavement, and it can be inferred from facts such as the presence of a uniform building line (the so-called 'setback': Fig. 2-2-2) that there are unwritten laws concerning architecture in the settlement area. As noted above, the irrigation system relies on roads and culverts; it can also be seen

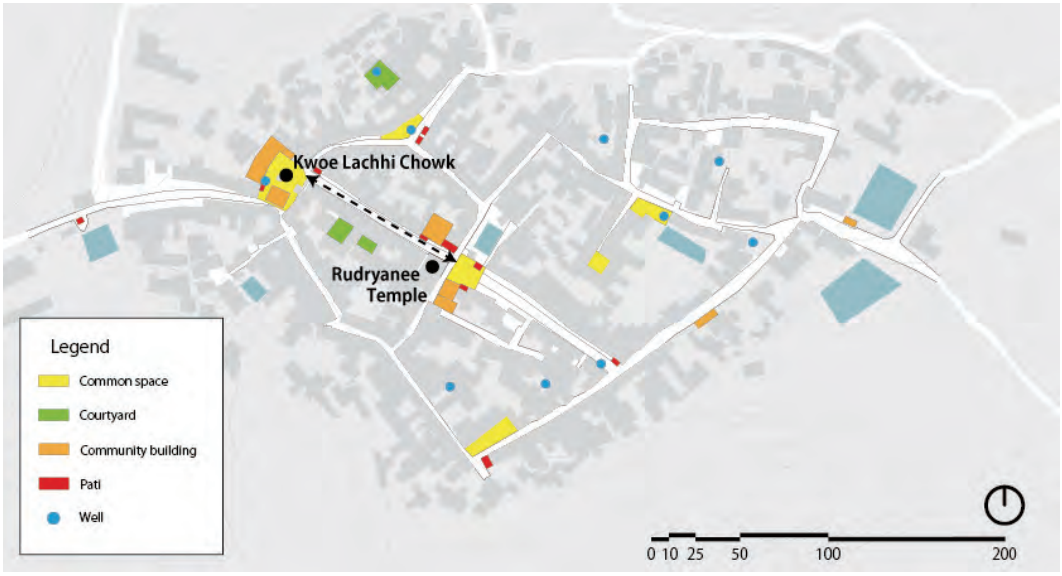


Fig. 2-2-4 Open spaces in the soutern settlement area


Fig. 2-2-5 Kwoe Lachhi Chowk at the festival (Taken on 25 Nov. 2015)


Fig. 2-2-6 Washing aside of the well (Taken on 23 Nov. 2015)


Fig. 2-2-7 Sun drying (Taken in Nov. 2015)


Fig. 2-2-8 Remains of debris from the earthquake at a courtyard (Taken in Nov. 2015)

that a planned division of street blocks has been implemented. Since the earthquake, the roads have been clogged with support materials to prevent buildings from collapsing, and there are, consequently, areas through where automobiles cannot pass (Fig. 2-2-3).

(3) Plaza

The plaza combines a small shrine, a well, a rest space, and a watering space with the space of the road. Here one can find various life activities, such as prayers, farm work, laundry, and daily conversation, in addition to courtyards that have now been turned into rubble storage spaces (Fig. 2-2-6, 7, and 8). At a festival held during the survey (November 25: Full Moon), a divinity was taken out from the Rudrayanee Temple down the main avenue; the festival was held with Kwoe Lachhi Chowk, featuring a musical band marching through the settlement area (Fig. 2-2-5).

(4) Religious space

As one of the features of Khokana Village listed on the World Heritage Site Tentative List is the fact that it enshrines both Chaitya (Buddhism) and the goddess Rudrayani (Hindu) . There are enshrined gods and pagodas everywhere (Fig. 2-2-9). Gods are also enshrined (Fig. 2-2-11) in the remaining space, and their number is uncountable. There was earthquake damage to the village's religious architecture. The small shrine at Kwoe Lacchi Chowk was rebuilt before the autumn festival with donations from and the cooperation of the residents (Fig. 2-2-10). It is understood that the Rudrayanee Temple is scheduled for repairs by the Department of Archaeology.

Belief pervades the villagers' daily lives. Every morning, there are people who purify their houses and purify the road nodes, called Doka; in the evenings, you can occasionally hear the performances of music bands. It may thus be said that the entire village is a religious space.

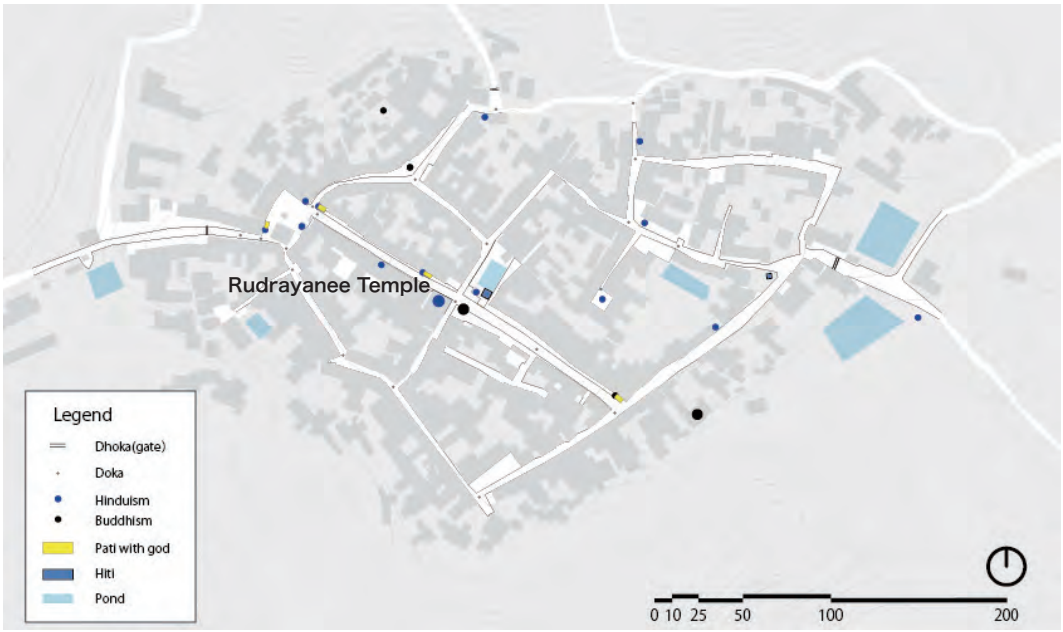


Fig. 2-2-9 Religious spaces in the southern settlement area


Fig. 2-2-10 Rebuilt small shrine (Taken in Nov. 2015)


Fig. 2-2-11 Pati hosting a god statue (Taken in Nov. 2015)

(5) Overview of changes

Among the drawings of the settlement area obtained during this survey is one source (Fig. 2-2-12) that was printed in 1969. In this research, we attempted to use this source to compare its details with the present situation (Fig. 2-2-13) to apprehend the changes in the settlement area. As outlined above, recent years have seen the population increase to approximately double its 1969 size. When comparing this drawing with the present situation, the expansion of the settlement area is clear. We were able to confirm three main trends to this expansion:

(A) new residential development on the settlement peripheries;

(B) extensions inside the residential block; and

(C) extensions to the settlement perimeter.

Subsequently, to confirm the changes in the neighbourhood's landscape, we compared a photograph from the 1970s (Fig. 1-1-3) to the present conditions . In the photograph from the 1970s, the Rudrayanee Temple soars in the centre and the traditional tiled-roof houses ranged and formed streets. Today, modernised buildings feature prominently and there are newer buildings whose heights rival that of the Rudrayanee Temple. It is apparent that, during the 1970s, there was a plantation in the courtyard space inside the residential block. It may be surmised that, unlike the current trend towards overbuilding, there were once courtyard spaces with access to sunlight. In addition to modernisation and overbuilding, the recent earthquake has complicated issues in the village.

Fig. 2-2-12 The southern settlement area in 1969 (From Goverment of Nepal: The physical development plan for the Kathmandu Valley, 1969)

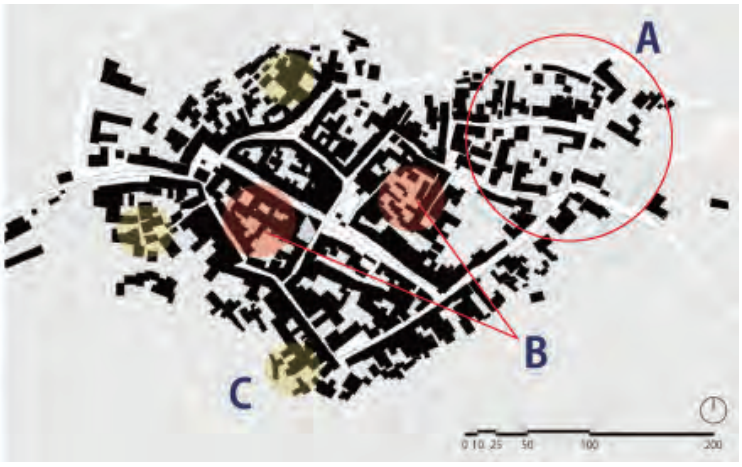


Fig. 2-2-13 The southern settlement area in 2015

2.3. Cultural Space

(1) Outline of the survey

The spatial elements of the traditional neighbourhood of Khokana include not just its buildings, but also spaces such as the streets and plazas and the faith-related elements located there, including small shrines; it also includes life around the wells and other areas. In many cases, these elements are intimately related to intangible cultural heritage such as faith and life.

'Cultural space' is also included within the category of intangible cultural heritage. Intangible cultural heritage generally evokes traditional performing arts and industrial artistic technique, but the concept of cultural space has also been presented not as these individual cultural expressions, but as the totality of the spaces where these artistic acts are actually performed and the life spaces of people who occupy the background of this artistic activity. We may cite Jemaa-el-Fnaa Square in Marrakesh, the Moroccan capital, as an example. There, a wide variety of people, including street entertainers and music groups, stall keepers, food booths, and tourists engage in various activities, and are listed as a whole as an expression of mass culture on the UNESCO Intangible Cultural Heritage List.

Together with our urban planning survey of Khokana, we also conducted a survey of elements related to these cultural spaces. This is because the preservation of these cultural spaces is indispensable to restoring Khokana while preserving its traditional neighbourhood.

(2) Survey on cultural space in Khokana

1. Element Mapping for Cultural Space

For our survey of the elements of cultural space, we identified a certain number of element types and employed the method of mapping their distribution. Identified elements considered to be important in current Nepalese culture are as follows.

- Small Shrine (Lacchi/Chaitya)
- Pagoda
- Buddhist temple
- Rest Space (Pati)
- Square
- Well
- Pond
- Water Area
- Mustard Oil Mill
- Others

Among these, there are both Hindu and Buddhist small shrines, and it appears that they are distinguished locally by calling the former Lacchi and the latter Chaitya. The pagodas are mostly of the stupa form of Tibetan Buddhism, and most of those situated in Khokana are small.

As may be expected, there are also Hindu and Buddhist temples. In Khokana, the representative temples are the Shree Rudrayani Temple in the centre of the village and the Shikali Maju Temple on the outskirts, both of which are devoted to worship of Hindu goddesses.

Rest spaces are locally called Pati, are often built in squares or by the roadside, and in many cases are cottages without walls. They are primarily used for resting, but frequently a divine image is enshrined there. Therefore, differences between pati and small shrines are vague.

Squares are divided between those that face the road and are comparatively wide and those in a courtyard that are surrounded by a building and comparatively narrow. In many cases, these squares contain facilities including small shrines, rest spaces, wells, or water areas and are public spaces for performing rituals and daily activities (e.g. laundry, threshing, etc.) At the present time, because waterworks have been installed, drinking water is taken from these waterworks; although well water is no longer used for drinking, it is now used for such purposes as laundry and dishwashing.

There are six main ponds inside Khokana, and it is thought that these are normally used as reservoirs for water used for farm work, but they are also stages where rituals are performed. In particular, the pond called De Pukhu located at the centre of the village is used as a place to slaughter many goats during festivals. According to legend, the divergence of the canal (Rajkulo) constructed by the king during the Malla period flows under Khokana as an underground canal; it is believed that the six ponds are all interconnected through this underground canal.

Water areas are narrow partitions where a spout or concrete water tank is set up around the perimeter; this establishes a space where water is drunk or daily tasks, such as laundry, are performed. It is likely that the spouts are of an older form and that the concrete water tanks have been newly established following the recent development of waterworks. Many of the water areas face the road and are set up so that all of the residents may use them.

The making of mustard oil in the village's mill is one of the main industries of Khokana. Its mustard oil making now receives special mention in the description of Khokana listed on the UNESCO World Heritage Tentative List; it is also considered an important cultural element. At one time, there were four mills, but only two are currently operating (as detailed further above).

Other important elements of cultural space include Shivalinga signifying a symbol of the goddess Shiva, the altars or worship places where sacrifices are made during festivals, symbolic trees, and crematoria along the Bagmati River.

The supplement 'The Khokana Cultural Spatial Elements Inventory' summarises these elements and conducts a distribution survey of Khokana and its surroundings. An exploratory onsite survey was conducted on 22 and 24 September 2015 and this survey was held from 22 to 24 November 2015.

2. Squares and Public Space

Amongst the elements related to cultural space in Khokana, we consider that the square is a particularly important spatial element. This is because the square is a public space where festivals and daily tasks are performed and also because we understand that the residents see the square as being culturally important (Fig. 2-3-2, 2-3-3).

In the process of mapping, we suggest that the types of squares in Khokana may be roughly divided into two categories. One is the "open type" and the other is the "semi-closed" type.

The open square faces the road, is comparatively wide, and is used on a daily basis by many of the residents. Examples that may be cited include the square called Chwe Lacchi located in the centre of Khokana Village (Site 23), the square called Kwelacchi surrounded by three Guthi buildings (Site 32), and Site 14, Site 22 and Site 28. By contrast, the semi-closed square is a courtyard surrounded by buildings and a comparatively narrow space. Site 7, Site 20, Site 27 and Site 29 may be cited as examples. According to interviews with residents, even the semi-closed squares are basically used as public spaces but they appear to be used and managed by a comparatively limited group of residents.

Both types of square often have facilities, such as small shrines, rest spaces, wells, and watering areas. This indicates that the squares are used as religious spaces and daily life spaces. In particular, the fact that wells and water areas are established in them indicates that water is central to public activities.

3. Cultural space in Khokana

Through this onsite survey, we learned that today there remain elements related to cultural space in Khokana Village. Some of these have been seriously damaged by the earthquake, but it has been confirmed that many elements and the religious and daily life activities related to them continue to exist. One point requiring attention for the future restoration of the neighbourhood is that reconstruction should be undertaken without drastically changing the constitution of this cultural space. Particularly with regard to squares, we anticipate there is a high possibility that the ''semi-closed type' will undergo change during reconstruction. This is due to the possibility that, in the process of rebuilding residential buildings, this narrow space will be used as residential land and will, consequently, disappear.

Moreover, we also learned that, in the cultural space of Khokana, elements related to water are important. In particular, the six ponds perform an important role even in rituals conversely, however, water

Fig. 2-3-1 Examples of a left: "open type" square (Site 32), and right: "semi-closed" square (Site 29)

Fig. 2-3-2 The map of the cultural space around the Khokana village

Fig. 2-3-3 The map of the cultural space inside the Khokana village

pollution is serious. Moreover, water pollution is indeed serious even for traditional water resources such as wells in squares. We will, therefore, focus on water-related elements in the next section.

(3) Survey of the water landscape in Khokana

1. The Importance of the water landscape in Khokana

Through the survey of cultural space in Khokana, we discovered the importance of water-related elements in the village. An important point here is that in the public space of the square, water resources such as wells and water areas are important spatial elements. Another point is that, as shown by the six ponds, water performs an important role in rituals and, simultaneously, the water landscape is also an important spatial element in Khokana's cultural space. In addition, most of Khokana's residents belong to the farmer caste and water is an indispensably important resource for conducting farm work around the village.

Because water elements have this importance in Khokana, we shall use the term 'waterscape' to refer to the various elements related to water.

The problem is that this 'waterscape' is on the verge of a certain type of crisis.

During this survey in November 2015, Associate Professor Kumiko Oguma of the University of Tokyo conducted a water quality survey for the pond and well water, and confirmed that most of the samples had reached levels of pollution unsuitable for drinking. In addition, at the time of the survey, many of the ponds were muddy and even malodorous. Today, because waterworks have been installed, ponds and wells are not used directly for drinking, but they are still used for laundry and farm work, leading to concerns about their ongoing impact. Furthermore, the pond water pollution is also seriously damaging to the aesthetic elements of Khokana as cultural heritage.

Therefore, in this onsite survey, we decided to conduct a survey also for the system of drainage water and to obtain basic information for the preservation of Khokana's waterscape.

2. The sawage system in Khokana

We conducted an onsite survey to apprehend the traditional sewage system in Khokana. To this end, we took the irrigation canals and the sewage system for street gutters as our subjects; the recently installed waterworks are not a subject of this survey.

According to legend, the water canal (Rajkulo) developed by the kings during the Malla period flows in the east of the village from south to north and its divergence is pulled into Khokana. It is also believed that in Khokana Village, the Rajkulo is an underwater canal that connects each of the six ponds together.

In the onsite survey, we were unable to confirm the existence of such an underground canal. However, we were able to confirm the presence of the irrigation canal thought to be a divergence of the King's canal (Rajkulo). Moreover, we also confirmed the direction

Fig. 2-3-4 Inside of Khokana village and its surrounding irigation and drainage system

of the water flow from the gutters of each of the village roads. This is because the sewage produced from the activities (such as laundry) in the square mainly drains into the street gutters. The attached Fig. 2-3-4 summarises these survey results.

Through this survey, we confirmed the divergence of the water canal thought to be the King's water canal (Rajkulo) being pulled into the village from the east and the circular flow of the canal outside the village. We believe this a system to supply water for farm work to the terraced paddy fields that spread around the village. Regarding the movement of water within the village, it was confirmed that the water is drained through the street gutters, generally following the topography from east to west. It should be noted that this drained sewage water flows directly into the abovementioned canal that surrounds the village, and is not part of a system that separates water for farm work from sewage water. However, the sewage water from the street gutter does not flow directly into the ponds. Nevertheless, in actuality, the possibility that sewage water is entering the ponds by seeping into the ground in times of heavy rainfall cannot be denied.

Looking at the sewage system of Khokana in this way, it may be understood that Khokana is a hub for providing water to the surrounding terraced paddy fields. As Khokana is formed at the edge of the topography on top of a mountain ridge, it is thought that an irrigation system was achieved by circulating water to the tip of the ridge through a manmade canal and, from there, supplying water in a radial pattern to the surrounding sloped land. In essence, we believe that Khokana's waterscape was a system in which the supply of water to the village and the function of an irrigation system were organically linked together.

3. Issues on the water landscape in Khokana

In this way, we believe that Khokana's waterscape was traditionally a logical system. However, we have found that, today, this system faces a serious problem of water pollution and is on the verge of a crisis.

We believe that one of the causes is the development of waterworks. Undeniably, the waterworks have allowed residents to access safe drinking water. However, we believe that this has separated the original drinking use from the water obtained from the water canal and wells and has thus invited the unexpected consequence that the pollution of the water resources used has, until now, been neglected.

We propose two measures for solving this situation. The first is to improve the water drawn into the village by the canal. Because this water is supplied through an open channel irrigation canal, it is possibly already polluted when it reaches Khokana. Therefore, we suggest it is necessary to take such measures as establishing a water purification plant to purify the water at the stage just before it reaches Khokana.

The other measure is developing the sewers. At present, the sewage water drained from the wells and water areas flows directly into the road gutters and, from there, flows into the water used for farm work. We propose it is necessary to develop sewers to prevent this sewage water from flowing into the farm work water and ponds.

In this way, by working to improve the water quality, the pond water will be cleaner than it is now and the aesthetic value of Khokana as cultural heritage will also improve. We believe that this will also lead to an improvement in residents' quality of life by allowing them to use well water more safely.

(4) Conclusion

Through this survey, we learned that not only the traditional neighbourhood but also the elements of cultural space perform an important role in constituting Khokana Village's value as a cultural heritage site. In particular, we learned that the waterscape is an especially important element of Khokana. However, it has also become clear that there are issues facing the preservation of these elements. Regarding the recovery of Khokana too, we propose that developing while preserving these elements of cultural space will guarantee its value as cultural heritage.

Undoubtedly, besides cultural space, rituals and other elements of intangible cultural heritage play an important role. However, as there remains much to learn concerning the apprehension and understanding of these elements, we would like to make their consideration an issue for future research.

2.4. Local Society

(1) Overview of the survey

The components of settlements of the Newari varied dramatically between town areas and agricultural areas due to both physical and social primary factors. The caste system was comparatively more strictly enforced in the town areas compared to the agricultural areas. Agricultural areas consisted of comparatively equal caste groups that utilized the agricultural space. Of all the Newari agricultural settlements, the prevailing theory is that Khokana is unique among them due its characteristic space configuration. In this chapter, we will investigate how space is utilized in the Khokana settlement through a multifaceted analysis of space, community, and other factors. These findings shall be arranged as assumptions in future proposals.

(2) Designations for spaces within Khokana

To understand spaces within settlements, vocabulary used to describe spaces within Newari settlements (that is, vacant spaces and squares, courtyards, etc.) has been arranged in Fig. 2-4-1. As a rule, the vocabulary used for spaces in Newari settlements have slight differences based on the geographic expanse. This is based on interviews with Dr. Shovana Bajracharya and Mr. Buddhi Ratna Dangol who provided on-site support for this survey.

Using the vocabulary for spaces described in the previous paragraph as a reference, if designations for Khokana spaces can be learned, they can provide clues as to how these spaces were formed, how the residents view the spacees, and how they are used. In this paragraph, we will describe how the regional society views these spaces based on interviews conducted with local residents.

1. Spaces within blocks

Spaces within blocks surrounded by buildings can generally be divided into two types: courtyard spaces that face house entrances, and backyard spaces that do not. These courtyard spaces are referred to as Nani or Chuka depending on their construction. There are two Nani and numerous Chuka within Khokana, and each has their own history and formation process. Conversely, backyard spaces were not specifically planned spaces, left as vacant areas without access to buildings or with access only to house back entrances (Fig. 2-4-2, 2-4-3).

1) Nani (planned courtyard)

Nani originally describes large vacant areas shared by the public. The fact these approximately 100sqm paved squares were shared by multiple families makes them unique. There are two such Nani spaces within Khokana (Dunecche Nani and Gabu Nani). These ancient Nani are thought to have been at least partially planned and constructed. Regarding their formation process, local residents believe that these spaces were enclosed during reconstruction in the aftermath of the 1934 earthquake according to interviews.

The religious facilities (small shrines) housed in both Nani also merit further attention. However, there also exist differences according to the period of their construction. Gabu Nani's shrines have been housed within the space since the courtyard was formed while Dunechhen Nani's Buddhist shrines were constructed ten years prior after the deaths of local residents.

	Newar name	Recognition for spaces	Function	Form	Sunshine
Spaces within blocks					
	Nani	Public	Open space (sometimes with worshipping place)	Large open space Not enclosed	○
	Chuka	Semi private - private	shared with neighbours	Enclosed space	△ ~ ×
Spaces without brocks					
	Lachi	Public	Its meaning is originally "outside house", and now widely used for outside space	Various form	Various condition
	Baha	Public	Spaces of Temple and monastery	Enclosed space	○
	Bohi	Public	Spaces around stupa	Enclosed space	○
Spaces defined by its function					
	Keba	Private	Vegetable field Sometimes sharing space	Inner yard but not necessary to be enclosed	○
	Saga	Private	Garbage hole or compost	Inner yard but not necessary to be enclosed	×
	Laybo	Public	Open spaces for aguricultural activities	Not enclosed	○
	Dabu	Public	Stage for festival	Not enclosed	Various condition

Fig. 2-4-1 Vocabulary for spaces in Newar Settlements

2) Chuka (other courtyards)

In Khokana, Chuka describes a private, vacant site for families or other groups enclosed by buildings. Compared to Nani, they are seen as private courtyards. In contrast to backyard spaces, these spaces face house entrances and are shared among multiple families. Size also varies greatly for each space. These spaces are used for laundry, cooking, personal hygeine, and other everyday activities. In contrast to Nani, shrines are generally not seen. Rather than being a planned space like Nani, these courtyards were naturally formed after being enclosed. Familes growing larger has led to the construction of new houses behind the original houses. Their entrances face opposite each other and form an enclosed area. Necessary through passages provide access from the front, and are shared by at most two or three familes. Furthermore, according to the interviews, small portions of sites were dedicated to maintaining the size of the courtyard space when new houses were built. Currently, new house construction and expanded reconstruction has caused original Chuka sizes to decrease and has reduced access to sunlight. For new house extension, minimum rules and guidlines should be defined to maintain a suitable Chuka space.

3) Backyard spaces

Other backyard spaces are vacant areas enclosed by houses within blocks without public access. They are not widely used, and when they are, they are mostly used for private needs. Most are utilized as storage areas, garbage disposal areas, and rubble dump sites.

Although space exists within these blocks, the lack of planning and overbuilding has negatively affected the environment making the spaces unsable in their current state.

2. Spaces outside blocks

Within the settlement, these spaces are road areas and squares outside blocks. Public squares referred to as Lachi are especially important in Khokana. Lachi's original meaning is "outside the home", and the word was used widely to describe public spaces outside. In Khokana, there are at least six clearly defined squares referred to as Lachi (Fig. 2-4-8). Three of this Lachi (Kwelachi, Chwelachi, Thalachi) are located on the main street and are of particular importance. They also play a major role in the religious festivals mentioned later. These three Lachi are also linked with the name of Twa.

3. Names for spaces by their function

As shown in Fig.2-4-1, the vocabulary refer to spaces also differ according to their function. Regardless of the spaces location within or outside of the block, these words only change with the space's function (Fig. 2-4-9 ~ 13).

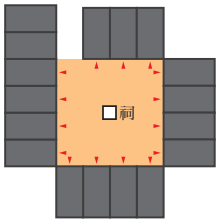
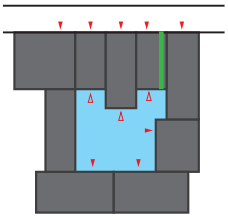
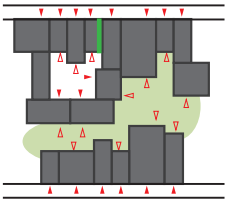
Spaces within Blocks		
Courtyard spaces		**Backyard spaces**
Nani	**Chuka**	
Public With road or passages Shared among multiple families Each entrance faces to courtyard With paving With worshipping small shrine Fromed by plan More than 100 m2 2 Nani in Khokana	Semi private ~ Private With through passages Shared among a few families Each entrance faces to courtyard Without paving basically Without worshipping place Formed gradually or naturally Various sizes	Private Through passages are not necessary Shared among Various number of families Without house entrance Without paving Without worshipping place Left spaces within blocks formed after house extensions Various sizes
Diagram  Public spaces without significant changes till now	Diagram  Maintained by neighbourhoods	Diagram  There are some cases where overbuilding caused inferior conditions

Fig. 2-4-2 Spaces within blocks

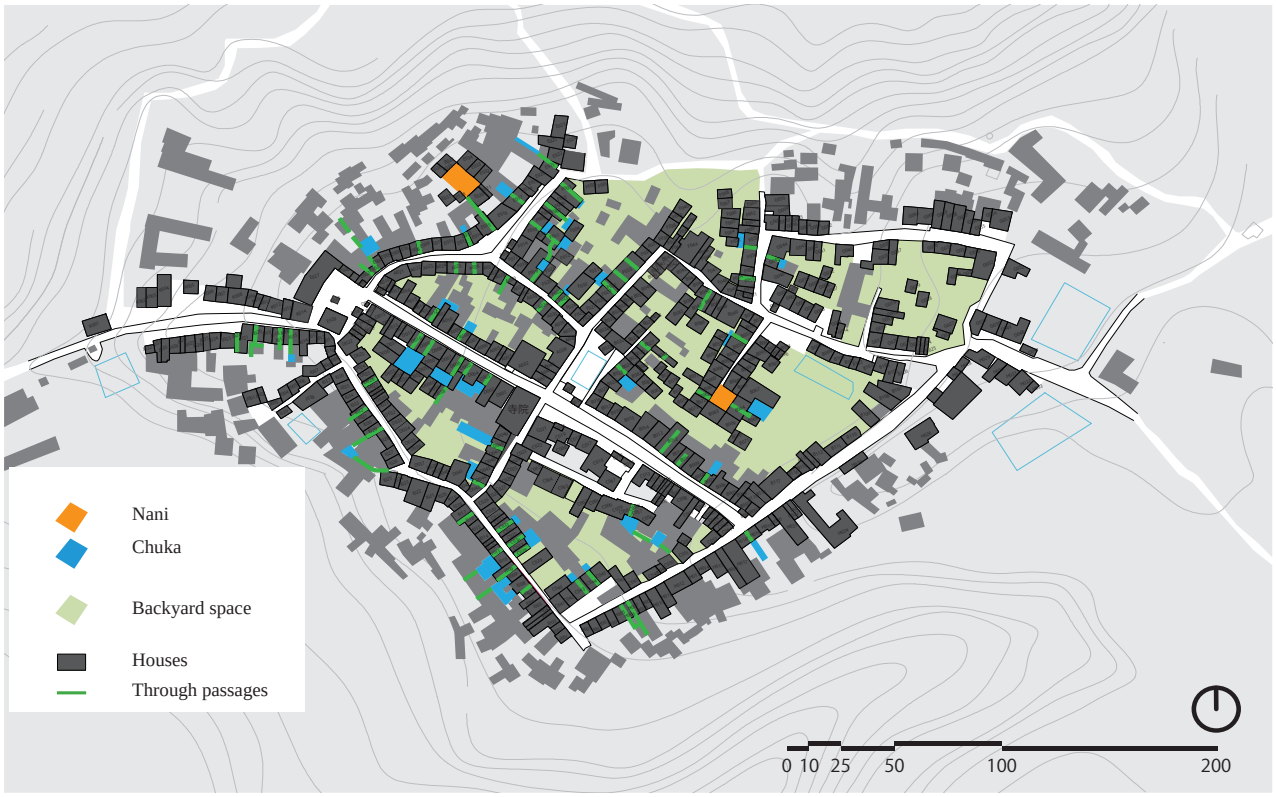


Fig. 2-4-3 Destribution map of spaces within brocks in Khokana

Fig. 2-4-4 Gabu Nani

Fig. 2-4-5 Dunechhe Nani

Fig. 2-4-6 Chuka of D010

Fig. 2-4-7 Backyard spaces of D033

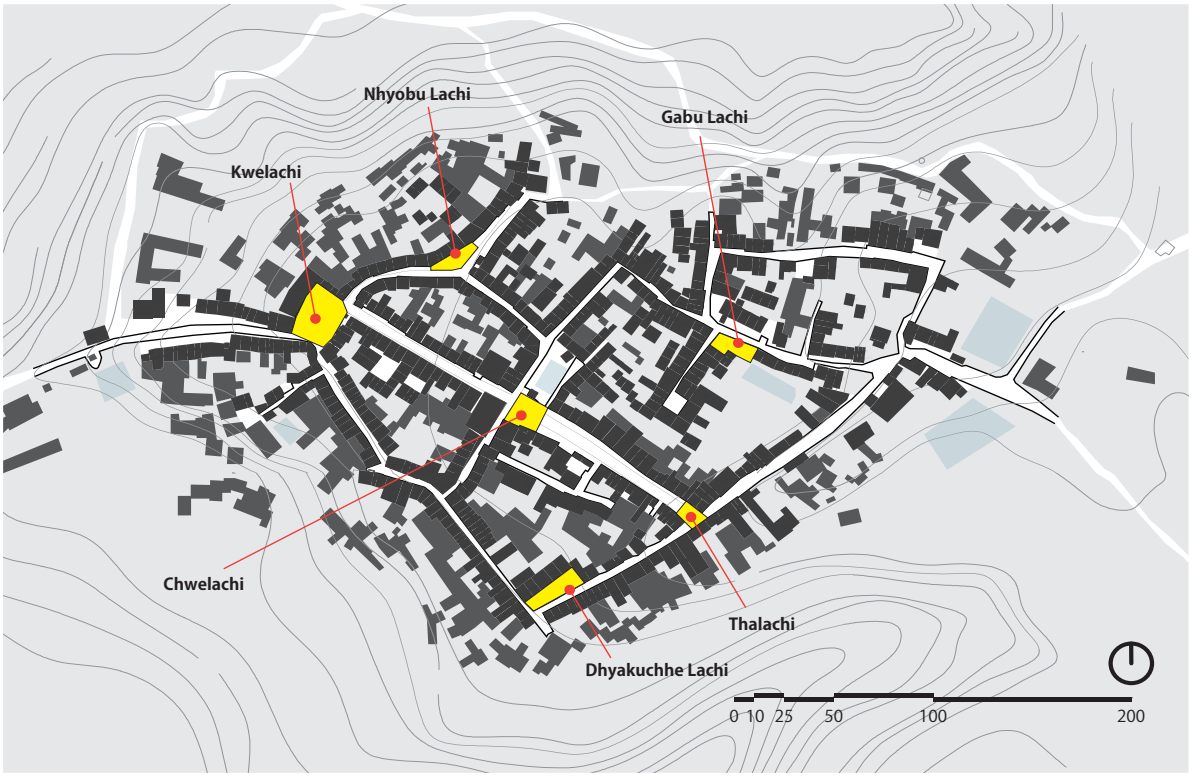


Fig. 2-4-8 Distribution map of Lachi in Khokana

Fig. 2-4-9 Morning market at Chwelachi

Fig. 2-4-10 A scene from the Festival at Kwelachi

Fig. 2-4-11 Vegitable growing at Keba

Fig. 2-4-12 Drying grain at Laybo

(2) Community and spaces in Khokana

1. Standard Tole (Twa) in Newari culture

Tole (Twa in Newari) are traditional communities within Newari settlements. According to Pant[1], they are both social and spatial units in traditional town settlements that generally correspond to neighbourhood communities For example, in the urban areas such as Bhaktapur where the one of the three kingdoms of the Kathmandu Valley were located, Tole (Twa) were used in the 14th century to segregate parts of the city according to social status. The Temple of Ganesha known as Tole Ganesha means that the temple had formed its own Tole[2]. In Newari agricultural settlements, including Satungal, there are currently 13 reported Tole. Within these settlements, each part of the community is referred to by its Tole name. The original 8 castes also each have their own Tole. The castes were thought to have lived arranged in order from the center to the edges of the community. However, in Satungal, new generations of families have built their homes in land between existing houses changing the structure of the settlement and mostly eliminating the caste-based Tole segregation. However, only the butcher caste remains segregated in a separate area[3].

	Meaning	Ex. Ward	New Ward	Muni. List	khokana.org
Thakhachhe	Large house	1	6	●	●
Nhyobu	Behind the field	1	6	●	●
Dunichhe	House at innerside	1	6	●	
Tajhya		2	7	●	●
Gabu	Lower field	2,3	7	●	●
Pam Pha		2,3	7	●	
Cho Chey	Branch families	3	7	●	
Gabu Lachi	Gabu square	3	7	●	
Dhokhapine**	Outside the gate	3	7	●	
Thalachi	Upper field	4,6	8	●	●
Bahalyune	Behind the temple	4	8		
Nanicha	Small passage	6	8	●	●
Dhyakuchhe	House at the corner	6	8		
Nayelan		6	8	●	●
Gare		6	8		
Kwelachi*	Lower square	1	9		
Kutupukhu	Kutu pond	5	9	●	●
Nayejho	Leader	7	9	●	●
Degalyune	Behind the temple	7	9	●	●
Dhokhashi	Near the gate	8	9	●	●
Chwelachi*		?	?		
Pukhushi	Near the pond	?	7	●	

Fig. 2-4-13 List of Twa in Khokana

2. Traditional Twa form

To investigate the original form of Twa in Khokana, we interviewed 94-year-old Mr. Bekha Lal Maharjan[4]. He described the

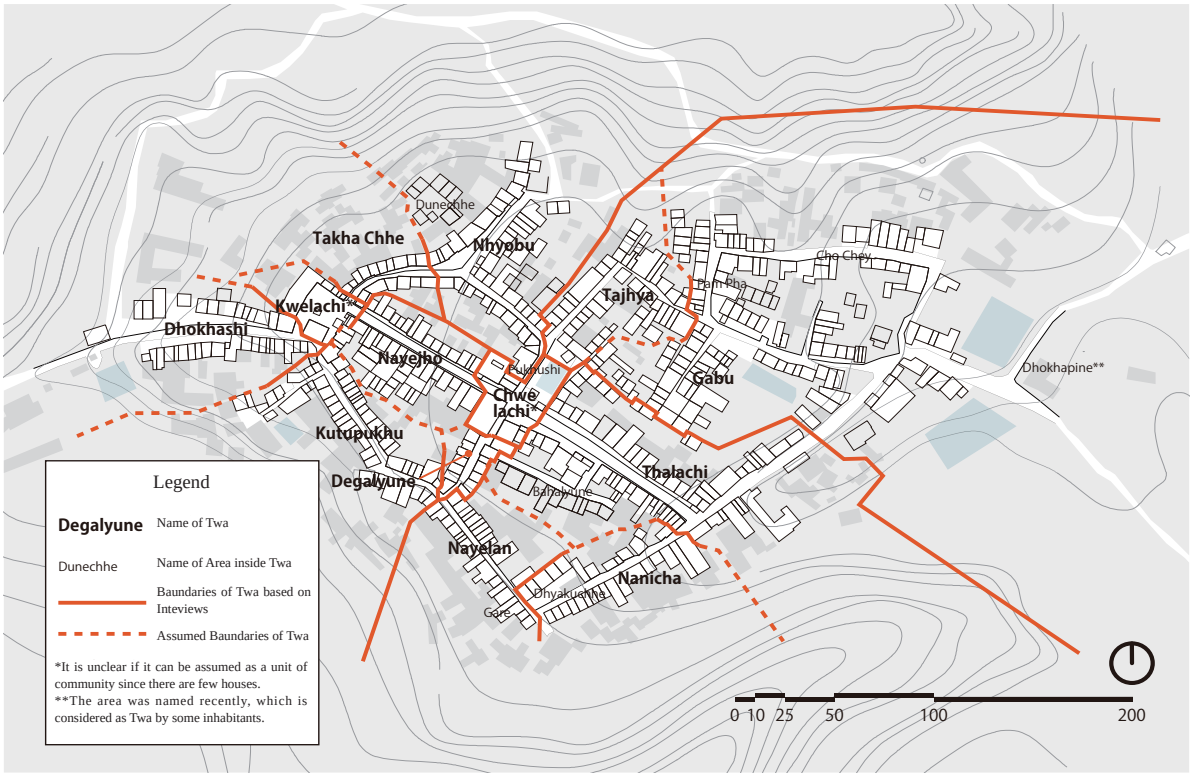


Fig. 2-4-14 Twa in Khokana

following.

Residents in Khokana determine a Khala[5], a sort of house name, for their family group. One Twa is formed from multiple Khala. For example, Gabu Twa consists of two Khala: Tepa and Khasun. Tajya Twa is home to the Katile, Gore, and Hapa Khalas. Each Twa is formed from multiple Khala, and Khokana is formed from multiple Twa, more than 11. The number of Twa has not changed since the time of their formation. However, recent years have seen outer Twa attributed to different people, and ambiguity regarding which places Twa extend to has produced deviations in counts.

During the annual religious festival held each September, young people from each Twa are chosen for the rite where they compete with representatives from other Twa for sacrifices of young goats in a pond. Local custom dictated that the winning Twa performs the Bhipyakha dance while touring all the other Twa in Khokana. Today, Twa are not required to choose a young representative.

3. The present state of Twa

In order to clarify the boundaries between present Twa in Khokana, the interview survey was conducted with the residents living around these boundaries[6]. In a similar fashion to Japanese ryogawa-machi (town on both sides of the street), most Twa were formed from familes enclosing a single street (Fig. 2-4-16).

A list shows the name of Twa, their meanings and their corresponding government-appointed Wards. Additionally, the Twa listed on the register obtained from the government[7] and the 11 Tole listed on the earthquake donations campaign website khokana.org[8] are marked. Names listed on Fig.2-4-13 in bold are Twa that were already present. There are 13 total. Conversely, names listed in small type are names of places that are not considered as Twa.

We found that of the 13 Twa, Chwalachi and Kwalachi are two Twa named for their significantly important squares (Lachi). However, these areas have few residents and are not listed on the government list. For these two Twa, it is difficult to conclude that Khala ever existed here and whether they were ever traditional Twa communities at all. It is more likely that the Twa designation was given to describe the location. The remaining 11 Twa after excluding these two are archetypal Twa communities of residents, and these 11 Twa are consistent with the list on the earthquake donations campaign website khokana.org.

However, extensions of houses due to growing families or relocations of residences within the village have gradually reduced the effectiveness of the Twa system. Now, the people living within a Twa are not necessarily part of its Khala. Additionally, due to expansion at the outskirts of the settlement, new places have been named, and there are examples of some of these new palces being treated like Twa (Dhokhapine[9], marked ** in Fig. 2-4-14). These areas on the outskirts are not considered to be Twa by older residents, but other residents treat them like Twa. The government list treats them like Twa for convenience and uniformity.

Modern Twa and Tole serve multiple functions as community units, place names, and government districting. Attention must be given to which of their multiple meanings is being used in context.

4. Government Ward and Twa

Twa community units were used in government districting. Wards were introduced in 1969 as a government districting tool, and Khokana VDC was divided into 9 Wards. Each Ward contained multiple Twa with their boundaries being established at Twa boundaries. Later, in 2010, Ward districting was changed with Khokana Wards No.5-8 being redistricted. Once again, Twa boundaries were used to establish boundaries. Current residents are

Fig. 2-4-15 Subdivision of Ward in 1969 (Quoted from "Goverment of Nepal: The physical development plan for the Kathmandu Valley, 1969")

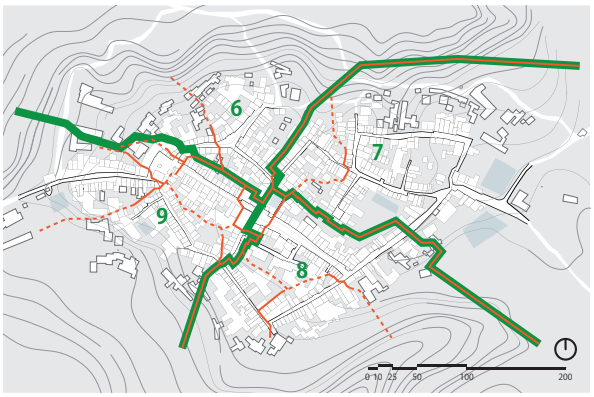


Fig. 2-4-16 Current situation of subdivision of Ward and Twa

aware of both Ward jurisdiction of Twa in addition to the Twa units themself.

5. Relationship of religious facilities and Twa

As mentioned previously, prior research into Bhaktapur has shown the temple of Ganesha, Tole Ganesha, as an organizing component of the Tole. However, temples of Ganesha are few in Khokana Twa. There is no indication that the structure of one Tole Ganesha forming one Twa or each Twa having their own temple of Ganesha is being used here. This is most likely due to Khokana's status as a small scale agricultural settlement and its highly homogeneous population. In addition, the Rudrayani Temple located in the center of Khokana where all residents gather to pray may be a factor as well.

A map of Khokana religious facilities (locations where multiple gods are worshipped are included) organized by color based on the god worshipped is shown in Fig.2-4-17. Dhokhapine merits specific attention for being an outer area with a shrine of its own (far-right mark of Fig.2-4-17). Three gods are worshipped here: Shiva, Ganesh, and Devi. According to the neighbourhood, the shrine was established approximately 15 years ago. It seems that the custom of worshipping Ganesha and the other gods has expanded along with the settled area. However, it is not common knowledge that Dhokapine is its own Twa. The establishment of a new shrine in Khokana does not necessarily mean the formation of a new Twa. The relationship between religious facilities in Khokana and Twa merits further investigation.

6. Relationship of resident surnames and Twa

A map of resident surnames[10] gathered through interviews is shown in Fig.2-4-18. Twa were originally formed from multiple large family groups called Khala. Due to the presence of multiple surnames even with the same Khala, it is difficult to determine with precision original Khalas and blood relations based on an analysis of surnames alone. However, trends can be established. For example, most residents of the southern Nanicha Twa have the surname Dangol, and many residents of the southwestern Kutupukhu Twa have the surname Maharjan. Based on these results, Twa seem to originally be communities rooted in familial and blood relations, and that trend has continued with modern Twa being home to many with familial or blood relations.

Furthermore, Maharjan and Dangol are overwhelmingly common surnames in Khokana. These surnames are associated with members of the Jyapu farmer caste. 97% of Khokana residents are part of the Jyapu caste[11]. This survey has confirmed that Khokana is comprised of more residents of the same caste than other settlements or town areas. Conversely, residents with the surname Sahi are concentrated in the Bahalyune area within Thalachi Twa, but these people are members of a different caste associated with butchers. However, this Twa does not only consist of members of this caste. The houses on the main street side of Thalachi Twa belong to a different caste, and the Twa's multi-caste composition merits special attention.

(3) Guthi and festivals

1. Guthi and spaces in Khokana

Guthi are Newari community organizations that conduct and pass on traditional ceremonies[12]. These groups are invited when babies, young adults, and brides are welcomed into the community through wearning ceremonies, coming-of-age ceremonies, and wedding ceremonies. They also cooperate when community members pass away for funerals . Only the head of each family can be part of the Guthi, and the member families of each Guthi has been determined long ago.

There are three main Guthi in Khokana. They are known as Ta Guthi, Ja Guthi[13], and Sala Guthi, and each is associated with their own relgious festivals and funeral services. How they relate to space is through their Guthi Buildings. All three main Guthi Buildings are located next to Kwelachi. These two-story buildings are also made using traditional construction methods. The second floor of each building houses a large open space. These spaces are reserved for altars during religious festivals, installation of portable shrines dedicated to goddesses, and other uses.

During the festival of the goddess in October, the three main Guthi each brew their own spirits in earthenware pots. The Thakali, or elder, of each Guthi will place these earthenware pots at their home (Ja Guthi, Sala Guthi) or Rudrayani Temple (Ta Guthi) and mature the spirits while playing music. This custom allowed us to identify the location of the Ja Guthi and Sala Guthi Thakali's homes through a survey conducted during a religious festival (Figure 2-4-19). Although this survey could not determine the addresses of every Guthi member, further study through additional surveys is warranted to see if there are trends in the settled areas of the three main Guthi.

Additionally, there exists another Guthi outiside the three main

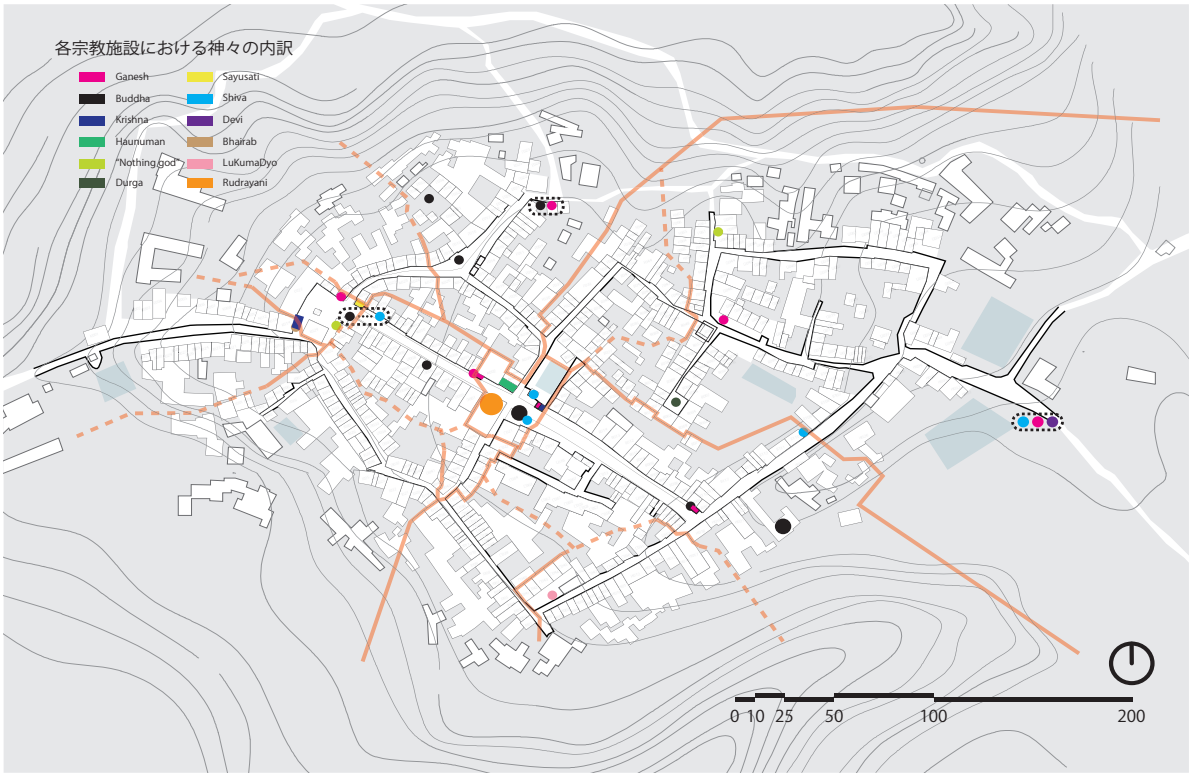


Fig. 2-4-17 Location of religious monuments and gods corresponding with subdivision of Twa

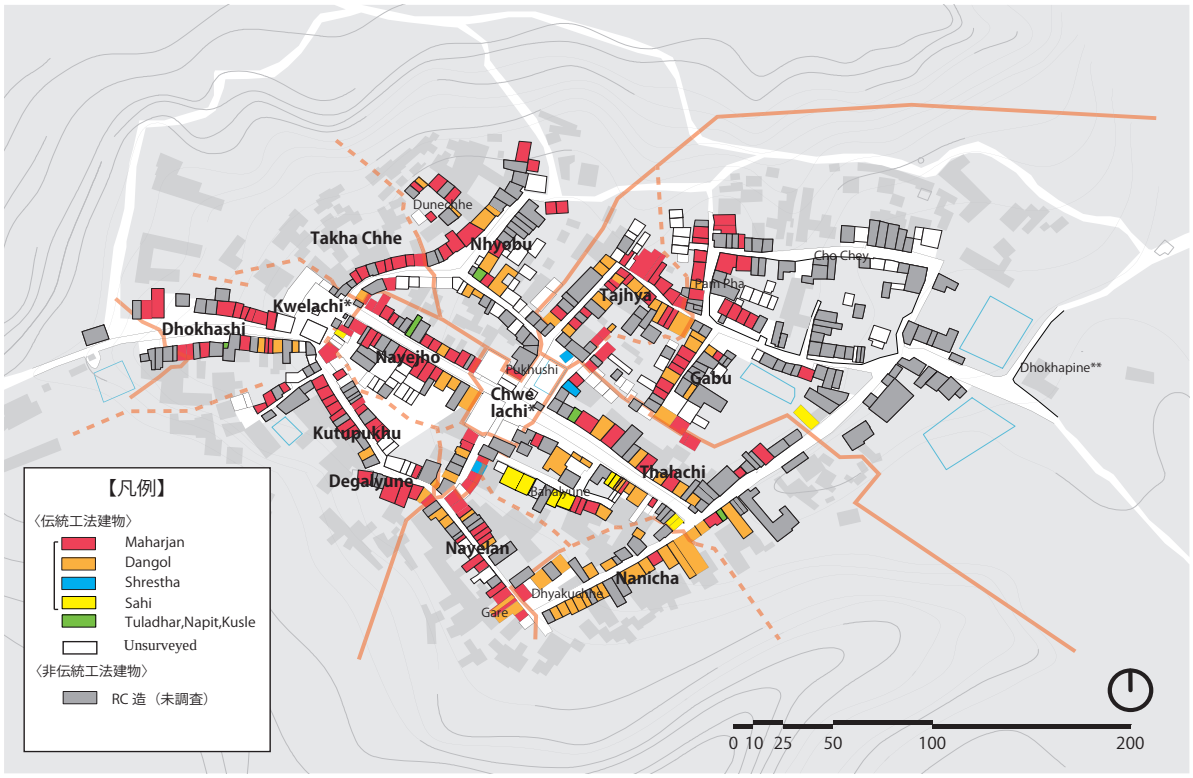


Fig. 2-4-18 Family names corresponding with subdivision of Twa

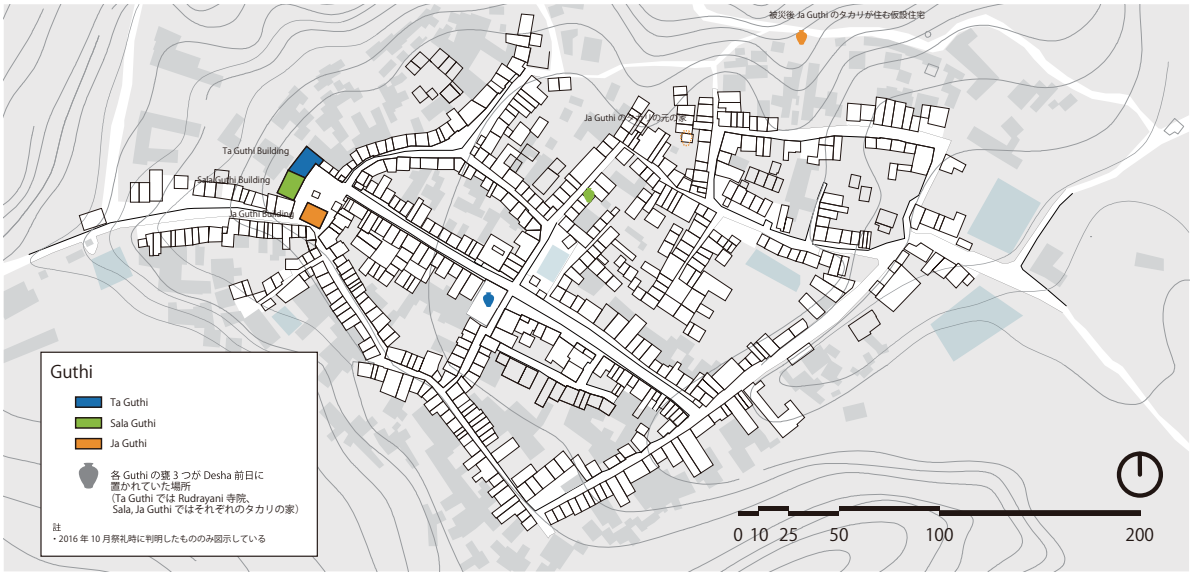


Fig. 2-4-19 Guthi building of three main Guthi

Fig. 2-4-20 Location of Rudrayani Guthi member's residences

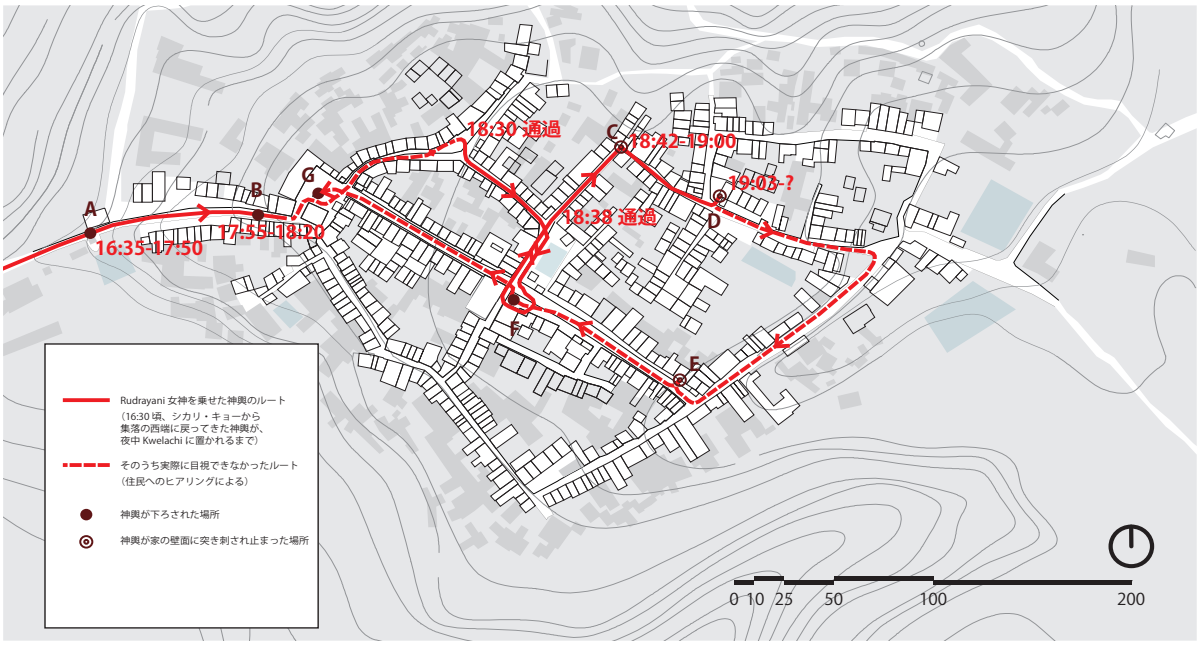


Fig. 2-4-21 Parade route of float in the festival Desha on 7th October, 2016

Guthi, Rudrayani Guthi. The Guthi derives its name from the goddess which is worshipped at the temple in the center of the settlement. It oversees the temple and traditional dances making it an extremely important part of the settlement. The Guthi consists of 46 male members, and similarly to other Guthi, all members are the head of their family. If the father dies, the son will inherit his position. For as long as the father is in good health, however, the son cannot participate, so the number of members never changes from 46[14].

This Guthi uses building A002 located directly in front of the Rudrayani Temple for meetings and other purposes. However, Rudrayani Guthi does not possess this building, instead, the building is shared by each Guthi. Through an interview regarding Rudrayani Guthi with member Mr. Hira Bhahadur Dangol, we identified the homes of 44 of the 46 members (Fig.2-4-20). The members are distributed evenly among all Twa in the settlement with no apparent bias. It is implied that the Guthi is supported by the entire settlement, but verification of this idea requires further investigation.

2. Spaces within the settlement during the October relgious festival

Khokana holds three major festivals annually in addition to a major festival once every twelve years[15]. This is custom is based in the settlement's worship its patron deity Rudrayani . The second festival of the year this past year coincided with the Hindu festival of Desain celebreated throughout Nepal. In contrast with other regions' Desain celebrations, Khokana celebrates in its own style[16].

During the festivities, a ceremony called Desha takes place. For this ceremony, portable shrines housing multiple gods are moved at 3-4AM from Rudrayani Temple to a square on the outskirts of the settlement called Sikhali Kyo[17]. There, a homa ceremony is conducted. After the ceremony, the portable shrines are moved back into the settlement at 4PM. The route it takes around the settlement each year remains the same. Diagram

Desha took placed on October 7th in 2016, and the goddess arrived at the entrance at the western edge fo the settlement at 16:35. After that, the portable shrines stopped at six locations within the settlement (see Fig.2-4-21 points A-F) during their tour[18]. Local area residents were welcomed to worship at the shrines while they were stopped at each location. When the portable shrines concluded their visit of each location within the settlement, they make their final stop and end their tour at Kwelachi (point G). The main god is enshrined within the Ta Guthi's Building bordering Kwelachi. The portable shrines are placed at the Kwelachi square and collected the day after[19].

The locations where the portable shrines stopped and welcomed local worshippers public squares called Lachi (points D, E, F, G:). The main stop was in front of a rest area called Pati (point A). Both locations are commonly used public areas. However, point B is in the middle of a street, and point C is at the corner of a street. The reason why these locations were selected in the past is unclear. These require further investigation.

Points C, D, and E are houses that have been modified through the opening of holes for the portable shrines. The portable shrines use these holes as a stopping point. The house at point D in particular was non-traditionally constructed using RC structure regardless, a hole has been prepared in the building. One can surmise that this was done to both renovate the building and retain its traditional signifance.

The portable shrines do not pass through Khokana's southern side (Kutupukhu Twa, Nayelan Twa, Nanicha Twa) during the annual religious festivals. The reason for this is believed to be the avoidance of an ancient corruption associated with local legend[20]. Furthermore, the southern side is only toured during the festival that takes place once every 12 years[21].

Notes:

1. SPATIAL STRUCTURE OF THE JYAPU COMMUNITY QUARTERS OF THE CITY OF PATAN, KATHMANDU VALLEY, PANT Mohan
2. Kido, Anri; Yamamoto, Naohiko; Masui, Masaya; Takeuchi, Yasushi. (2012) 6030 A study on the constitution of urban tissue in Bhaktapur, Nepal No.3: Living activities outside of houses aligned with tol boundaries [in Japanese], 2012 Tokai University Academic Lecture Series: Architectural Design. Academic Lecture Summary, 2012, 59-60.
3. SATUNGAL, A Newar Village ("4 Villages, Architecture in Nepal", pp.55-59)
4. Thakali (Elder) Ja Guthi
5. Newari Language The word translated directly means "Group" and is similar to a business name in Japan. The Nepali word is Khalak According to Mr. Sobana, each Khala is named as a part of their respective caste. Khala names do not necessarily relate to their occupations, rather, they are thought of as nicknames. Each Khala contains people of differing surnames, but people in the same Khala were all orginally part of the same family. Each Khala also hosts their own unique events. Furthermore, each Khala's members are also subject to their chosen Guthi.
6. It must be remembered that these boundries are what the residents perceive them to be. Whether they have served as official boundry lines since the beginning requires more investigation.
7. Resident register for distribution of subsidiary aid obtained from the Khokana Municipality Office November 2016. The Twa of people recorded on the register were listed. The names of the Twa listed on this government list are used not only to denote the traditional community to which their residents belonged to, but also as convenient substitutes for addresses given that all areas within the settlement and on its outskirts are named by their Twa.
8. Accessed October 2016.
9. Dhokhapine is a place located close to Khokana's bus parking lot. In the past 20 years, the area has expanded rapidly as a new settled area.
10. Residents were asked for their surnames during the survey regarding reconstruction conducted by Prof. Mori (Tokyo University). Only residents living in buildings made using traditional construction methods were asked to participate.
11. Cited from Barjracharya, Shovana; Living in Khokana: The miracle of the Khokana in the Kathmandu Basin [in Japanese], 2008, pp.26
12. Cited from Barjracharya, Shovana; Living in Khokana: The miracle of the Khokana in the Kathmandu Basin [in Japanese], 2008
13. Also known as Jamgu Guthi.
14. This is as told by Mr. Krishna Hari Dangol in an interview by Rudrayani Guthi elder Mr. Dhan Bhahadur Dangol.
15. Cited from Barjracharya, Shovana; Living in Khokana: The miracle of the Khokana in the Kathmandu Basin [in Japanese], 2008, pp.76
16. Ibid, pp.80
17. The reference for the location of the Sikhali Kyo (Sikhali Temple) and the route to the location during religious festivals is the Project for investigation of damage situation of cultural heritage in Nepal: Historical settlements survey report [in Japanese] pp.12 published March 2016.
18. The earthenware pots containing spirits mentioned in the preceding section are also collected, taken to Sikhali Kyo, and participate in the tour on the same day. The pots precede the portable shrines forming a line before being taken to their respective Guthi building upon the tour's conclusion.
19. On the following day, October 8, 2016, a traditional dance called Pyakha took place in Kwelachi for most of the day.
20. As told by Mr. Bekha Lal Maharjan.
21. As told by Mr. Jeevan Krishna Dangol.

Fig. 2-4-22 Float receives worshipping from inhabitants at Stop A

Fig. 2-4-23 Holes on the facade for a float at Stop D

2.5. Local Industry

(1) Overview of the survey of mustard oil

Unless otherwise noted, the contents of this section are based on interview surveys conducted with two managers of mustard oil mills in November 2015[1]. As these were limited interview surveys conducted with two individuals through interpreters, it is necessary to corroborate them with documentary records in the future.

(2) Mustard oil in the Kathmandu Valley

Mustard oil is a cooking oil for daily use not just in Nepal, but also in northern India and Bangladesh. It is manufactured by heating and pressing leaf mustard seeds and is also used for massaging small children, applied to the skin and scalp to prevent dryness, and for religious ceremonies[2]; it thus may be called a product that is intimately connected to life.

Khokana is well known as a producer of mustard oil. On the World Heritage Site Tentative List, it is designated by the title 'Khokana, the vernacular village and its mustard-oil seed industrial heritage'. The description of the value of mustard oil highlights that 'It houses chaityas and a Mother Goddess temple. The mustard-oil seed industry has become the living heritage of the village'[3].

The farming villages of the Kathmandu Valley and particularly the peripheries of Khokana have long cultivated leaf mustard in addition to rice, and mustard oil manufacturing has traditionally been performed in each farming family household. Because, in comparison with transporting the seeds that are the raw material for this product, mustard oil is comparatively light and high in value, there have been periods during which it was used to pay taxes to the ruling lords of the Kathmandu Valley.

(3) The history of mustard oil production in Khokana

The village of Khokana established its policy of intensifying mustard oil manufacturing as its main industry during the agricultural off season, when there is less farm work to do, approximately 400-500 years ago. In terms of individual endeavours, commonly owned mills with equipment were established and mustard oil manufacturing was started. With each stock having the value of 50 pice, by issuing approximately 150 stocks per mill (for example, Gabu mill had 142 stocks, while Nhu mill had 152 stocks) and raising funds, a mill building and instruments for heating and pressing were established. In terms of the whole village, there were at one stage at least four mustard oil mills. The exact period in which these mills were established is unclear, but according to the interview surveys, Gabu mill is the oldest, with Kutu and Nhyabu mills being constructed later, and Nhu mill is the newest.

Before the mustard oil mills were established, each family used the leaf mustard seeds produced on farmland around the perimeter of the village as raw materials. However, with the establishment of the mills and the improved efficiency of pressing work, production quantity increased and the raw materials produced on farmland around the perimeter of the village were no longer sufficient for its residents' needs. Consequently, people in the village began to collect leaf mustard seeds from the entire Kathmandu Valley. We were told that barter exchange was sometimes used to obtain raw materials by carrying the Khokana mustard oil to faraway villages a 2-3-day walk away. At that time, leaf mustard was widely cultivated in the Kathmandu Valley, together with rice growing; however, because Khokana intensified and increased the efficiency of mustard oil production through mills, it became widely known as a producing area for mustard oil.

At the time the mills were established, rules concerning their use were created and investors held the rights to alternate in using them. Consequently, each farming household used the mill system by collaborating with relatives and acquaintances, using the mills to squeeze the seeds they had produced on their own, distributing them as mustard oil to collaborators, and each of them taking the mustard oil home with them. Nowadays, squeezers that can be operated by just one person have been introduced, but at the time the mills were created, human weight was used to squeeze oil from the seeds, a job that we were told required 15-16 people; working as a community comprising mainly family and relatives was the general rule. It is unclear whether investors and the groups that performed the pressing work were related to each other through geographical ties in the village.

(4) The location and history of each mill

As detailed above, at least four mustard oil mills of a relatively large scale were constructed in Khokana and used by investors. The location of each mill is illustrated in Figure 2-5-1. According to our interview surveys, the ages of the mills in descending order are as follows:

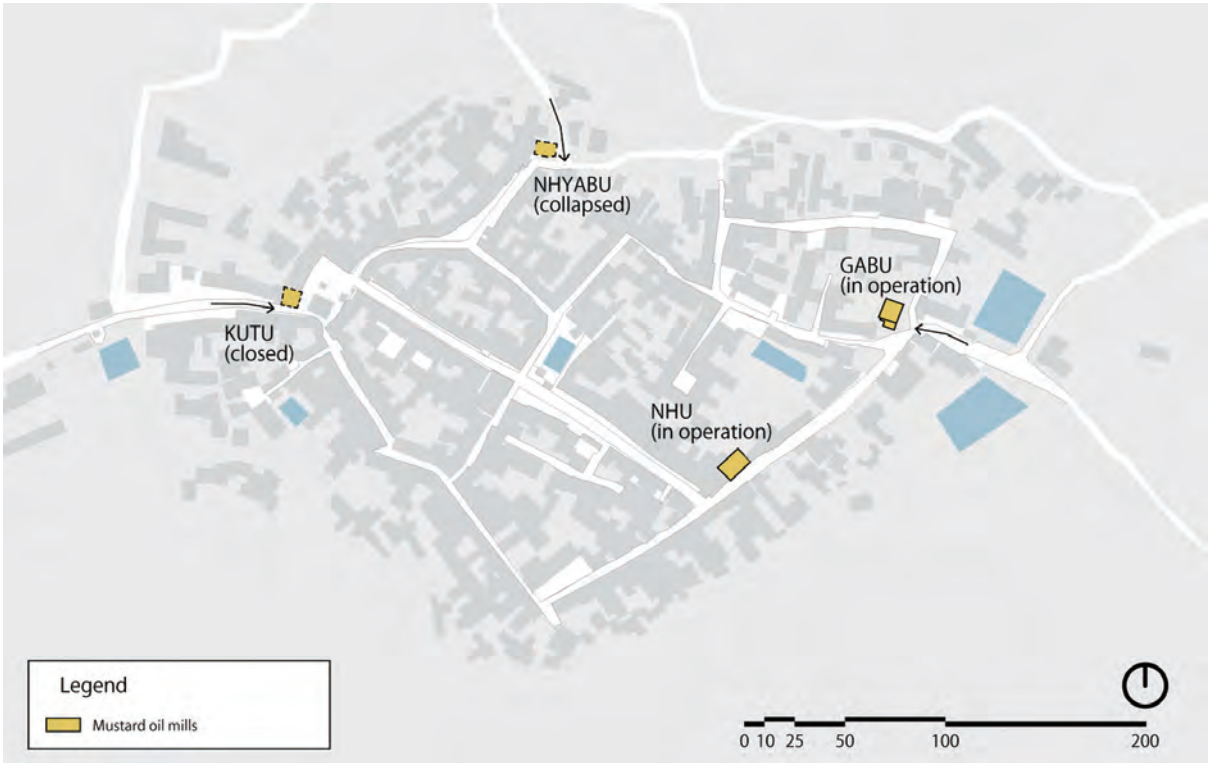


Fig. 2-5-1 Location of main mustard oil mills in Khokana (Yellow) and main route into the village (Arrow)

Fig. 2-5-2 Gabu mill (In Operation, the portraits on the above of buildings are victims in Khokana by the earthquake)

Fig. 2-5-3 Kutu mill (Closed)

Fig. 2-5-4 NHU mill (Closed)

Fig. 2-5-5 Nhyabu Mill (Collapsed)

- the mill at the village entrance is the oldest (the main users are the residents of Districts 2 and 3);
- it is followed by the mill within the Main street (part of District 5 and Districts 7 and 8), and the mill to the north of the village (District 1 and part of District 5) as third oldest; and
- finally, the mill that we interviewed is the youngest (Districts 4 and 6).

The mills are positioned along paths that enter the village from outside. Mustard oil squeezing requires many people and we were told that because there were many people at the mill during the evening, placing mills at the village entrance was also for security purposes. We also heard the opinion that because mustard oil produces a distinct smell when it is heated, the mill had to be located at the edge of the village.

(5) The decline and revival of the mustard oil industry

Partly because mustard oil requires considerable work to extract, when cheap vegetable oil came to be imported from countries such as India, Khokana's mustard oil industry severely declined. Around thirty years ago, Khokana's mustard oil mills closed and its buildings were left to stand empty. To raise the mills' efficiency, equipment improvement and, in particular, the purchase of a presser was necessary. However, because each mill had many investors, decision-making for new investments proved to be impossible, leading to the closure of the mills.

In 1999, through support from UNESCO's Kathmandu office, two mills were restored and restarted their operations. At the Gabu mill, a new management team of several people was formed, and production was restarted after borrowing the entire mill from all its investors and recruiting new mill operators. The Nhu mill is now run through a cooperative union of investors, but the mill's operation is conducted by the members who responded to our interview survey.

Whilst they were once gathered as raw materials throughout the Kathmandu Valley, including the villages surrounding Khokana, the majority of the mustard seeds processed in the village is now sourced from outside the region. Raw materials are imported domestically from areas outside the Kathmandu Valley, such as the Terai plains region close to India, and from abroad, from India, Europe, and elsewhere. The leaf mustard seeds cultivated around Khokana are still used intermittently today, but it has been recognised that the use of compost on surrounding farmland has decreased and been replaced by chemical fertilisers, resulting in the impoverishment of the land. Whereas previously 7-8 litres of oil were squeezed from 25kg of raw materials, in recent years, this has decreased to 4.5-5 litres.

Today, the residents of Khokana and neighbouring villages, searching for high quality oil, still purchase mustard oil directly from the mills, and deliveries are also made to some of the department stores in Patan.

(6) The process of mustard oil production in Khokana (the example of Gabu mill)

The raw material of mustard seeds is first roughly ground and carried to a giant oven with the surface of the seed with the mustard colour inside. Inside the oven, workmen continue carefully mixing the seeds and continue to heat them until their unique and aromatic scent emerges. The unique aroma that fills the mill is produced from this heating of the raw materials.

The heated seeds are stuffed into a flat and tightly woven basket, gripped between two large wooden beams about 40cm in length, and squeezed. Of the two beams, the end of one is fixed in place beforehand, and the end of the other is held by a vice-like device with a large handle about the length of a person's spine. After depositing the seeds into the woven basket and inserting them between the beams, a workman uses all of his weight to turn the large handle and thereby squeeze the seeds.

The bottom of this traditional squeezer is formed in a dug state, so that the brown-coloured mustard oil that oozes out of the woven basket collects in the container of this dug state part of the basket. The top of the woven basket opens widely and the bottom is a sharp-edged pentagon, with one part designed to gather oil effectively. According to the owner of the mill, the squeezing method is traditional and is still employed despite the fact that it requires much work because it greatly improves the quality of the oil.

After the first squeezing process, the pomace is like a hardened cake inside the woven basket, but it is then finely crumbled a second time and deposited into the next squeezer, which is mechanical. The oil squeezed from a mechanical squeezer is strong coloured and somewhat poor in quality, but because squeezing oil solely according to traditional methods would be economically infeasible, the Khokana product is a mixture of the oil generated by the first squeeze using traditional methods and the product of the second squeeze by machines.

Fig. 2-5-6 The grinding mill for mustard seeds

Fig. 2-5-7 Compressor using the traditional technique

Fig. 2-5-8 The way of compressing using the weight of the workman

Fig. 2-5-9 Mechanical compressor used for second squeeze

Fig. 2-5-10 Cooker heating grinded -mustard seeds

Fig. 2-5-11 Putting roaseted -seeds into the compressor

Fig. 2-5-12 Squeezed mustard oil (First squeeze)

Fig. 2-5-13 Crushing pomace of first squeeze

(7) Possibilities and issues for Khokana mustard oil

As this section has summarised, the production of mustard oil was originally an overwhelmingly local industry that started from processing raw materials produced from farmland around the village using labour during the agricultural off-season. The residents of Khokana promptly established commonly owned mills, conducted oil squeezing efficiently, and succeeded in making the production of mustard oil a primary industry of the village following farming. The trading centres for raw materials spread as far as the surrounding farming villages of the Kathmandu Valley, but as may be seen in the barter trade of raw materials and oil, production and consumption may be interpreted to have been a continuous industry that was self-consumed within a certain region.

In recent years, however, with the advance of urbanisation in the Kathmandu Valley, the majority of raw material production became reliant on areas outside the Kathmandu Valley. Mustard oil produced with modern equipment and other cheap vegetable oils circulate on the market and Khokana mustard oil produced with traditional methods is uncompetitive in terms of price. The high quality of Khokana's mustard oil is widely recognised, but that quality is highly dependent upon traditional squeezing methods that require manpower, making it difficult to compete in the same arena with general vegetable oils produced in factories.

It will be necessary to consider how to raise Khokana mustard oil's added value and develop it into an economically sustainable traditional industry by sharing with consumers both the scenery of the terraced paddy fields, where leaf mustard has long been cultivated, and the realities and merits of a manufacturing process that requires human hands (traditional squeezing methods). Simultaneously, it is also important to encourage the regional residents themselves, who are the biggest consumer of Khokana mustard oil, to understand their local mustard oil industry. A hint as to how to achieve this may be hidden in the origins of the mustard oil mill, in which village residents have used the equipment in shifts and helped one another to squeeze oil.

At present, there are only two mills in operation, but as noted above, each mill is located near to the village entrance, so that in terms of the village structure also, the former sites of mills are located in important positions. Establishing a simple facility for promoting understanding of traditional industries that support Khokana's development, through means such as the understanding of mustard oil production using buildings and land and experiencing traditional squeezing, may be a useful means of deepening the understanding of traditional industries among visitors and residents.

Notes:

1. Dates of interview: Gabu Mill 2015/11/24, Nhu Mill 2015/11/25
2. Luke C. Mullany et al., Traditional Massage of Newborns in Nepal: Implication for Trials of Improved Practice, Journal of Tropical Pediatrics, 51 (2): 82-86, April 2005
3. UNESCO, World Heritage Centre, Tentative Lists, quotation from the section on Khokana, http://whc.unesco.org/en/tentativelists/844/, last checked on February 26, 2016

2.6. Townscape

(1) Outline of the survey

Since the 2000s, the division of the land, extension and renovation of houses, and construction of high-rise houses of reinforced concrete have been carried out to a remarkable extent that the vernacular townscape valuable as World Heritage has been radically transformed. In 2015, when the large-scale earthquake struck the Gorkha District, the maintenance of the traditional townscape became a more critical situation as the old houses were damaged or collapsed much more than the latest buildings of reinforced concrete.

According to the residents, every house but four collapsed in Khokana in the earthquake of 1934. After that disaster, the new townscape of Khokana was reconstructed from ruins. Khokana has a long history , however, its townscape may be considered fairly new because even the oldest buildings there were constructed only 90 years ago, except the four buildings which did not collapse during the disaster of 1934. On reflection, we could say that Khokana's townscape has a history spanning three or four generations.

After the 1934 earthquake, it is considered that almost all of the village's houses were similarly reconstructed in their pre-disaster form. The situation after the 2015 earthquake is different from that of 1934 because reinforced concrete houses and damaged traditional houses have remained intact. This time, the village itself needs to be rehabilitated. 'The Khokana Reconstruction and Rehabilitation Committee', a local private organisation mainly formed by young people, has devoted efforts to rehabilitate the traditional townscape at the opportunity after the disaster. Khokana residents, however, had already transformed their townscape before the 2015 disaster, with extension of their living spaces, changing their lifestyle, and extension or reconstruction of their houses using reinforced concrete. Considering this situation, it is difficult to realise the rehabilitation of traditional townscapes without taking into consideration their demands for living spaces.

The Khokana Reconstruction and Rehabilitation Committee intends to rehabilitate the traditional townscape. This does not mean directly rehabilitating that townscape by restoring the existing historical buildings, but also involves creating new houses in a traditional style. For example, the Committee conveyed to us their opinion that the traditional style buildings constructed before the 2015 disaster – those built in a similar but different style to the originally traditional houses of Khokana – were ideal. Therefore, it is necessary to share the future image of the townscape and special design of Khokana not only with professionals and voluntary organisations but also with the local residents.

We need to begin the rehabilitation process from the present situation that the village is characterised first by the co-existence of traditional houses and contemporary high-rise housing and second by the great earthquake that struck in 2015. In examining the future vision for the rehabilitation, we first need to focus on the evolutional process of Khokana's townscape, from the spatial situation of reconstruction after the 1934 disaster, through to the 1996 townscape when Khokana was evaluated as a World Heritage candidate, and finally to the current townscape. We will not consider single houses that have been already divided, but focus instead on the original housing units and their lots, as reconstructive units. We will also focus on the spatial composition and the common use not only of the houses but also of courtyards and through passages, to enable us to show the future vision of the rehabilitation of the village with its spatial characteristics.

The objectives of this investigation are to comprehend a) the transformation of the townscape after the 1934 earthquake and b) the spatial transformation of traditional houses according to the actual demands of residents or changes in the life stage of each family in order to plan the rehabilitation of the traditional townscape. In essence, we are going to clarify:

1. the causes of the transformation of townscape; and
2. the units of the housing lots that should be considered as one for planning the rehabilitation of the traditional living space and its transformation

Nyala Dan (Nayajho) Street is one of the most important streets of the Khokana townscape, from Shree Rudrayani Temple, located in the centre of Khokana, to Kwelachhi Chok. However, with recent reconstructions along this street, the townscape has changed significantly in comparison with that in the aerial photograph of 1973 (Fig. 1-1-3). Exacerbating this situation, the existing traditional houses were damaged by the April 2015 earthquake. Aside from Shree Rudrayani Temple, the common facilities, and Pati (small arbour) at the end, all the buildings in the investigation site are used for housing even there are stores on the ground floor.

During the field survey, occupation of most of the traditional houses was prohibited by the government according to the extent of damage, and those houses need to be restored or rebuilt urgently. Thus, it is difficult to restrain the reconstruction of traditional houses into contemporary ones without establishing any regulations. There is anxiety that the future townscape could be quite different from the former one on World Heritage Tentative List.

In this investigation, we studied on prior research and related documents, collected photographs from websites, and conducted a field survey. From 2 to 6 December 2015, we interviewed residents of Nyala Dan Street about the changes of use of houses and courtyards, family compositions and other relevant issues using interview sheets (Tab. 2-6-1).

There are 38 houses which remained even with heavy damage after the 2015 disaster along Nyala Dan Street; we interviewed the residents of 18 of these houses. We also interviewed the residents of four houses (all of which are recorded on the 1969 map) which front the courtyard in order to understand the changes at the rear of the street. We interviewed in the morning and evening because the residents are engaged in farming during the day. A Nepalese interpreter (Japanese-Newari) assisted this field survey.

(2) Analysis of transformation of townscape along Nyala Dan street

1. Analysis of documents

We arranged the site plan of Khokana prepared in 1969 and aerial photographs from 2003 published on the Google Earth website in chronological order, then analysed their morphological changes over periods of 10 years.

The site plan drawn in 1969 shows the roof shape of each building and, we understand, the whole spatial structure of Khokana, including the crossroads at the centre and the situation of houses with courtyards. This plan is consistent with the aerial photograph of 1975, so we consider the source of investigation of 1969 to be reliable. We thus superimposed this plan on the current aerial photograph and compared the arrangement of houses and

Fig. 2-6-1 The investigated site (Quoted from Google earth, taken on 8th June 2015)

Tab. 2-6-1 List of the houses and residents

Investigation number	Building number (A)	Building number (B)	Date of investigation	Name (Interviewee)	Age	Occupation of householder	Number of family
1	S05-b	-	2. Dec. 2015	S. L. Maharjan	80	Magician	4
2	N08	A011	2. Dec. 2015	N. G. Tuladhar	66	Retired	3
3	N19	A004	2. Dec. 2015	B. K. Maharjan Apa	60	Carpenter	6
4	S15	D004	2. Dec. 2015	H. N. Dangol	73	Retired	2
5	S14-b	-	3. Dec. 2015	M. K. Dangol	59	Farmer	6
6	N13	D006	3. Dec. 2015	J. B. Maharjan	80	Retired	5
7	N12	A008 East half	3. Dec. 2015	R. Maharjan	38	Carpenter	4
8	S16	D003	3. Dec. 2015	S. K. Dangol	33	Bike repairer	3
9	S09	D009	4. Dec. 2015	H. L. Maharjan	70	Farmer	3
10	S10-b2	-	4. Dec. 2015	J. B. Dangol	46	Farmer	2
11	N01	A018	4. Dec. 2015	A. Maharjan	42	Farmer	6
12	N07	A012	5. Dec. 2015	K. Maharjan	59	Farmer and Shop owner	9
13	S03	D015 East half	5. Dec. 2015	A. Maharjan	22	Farmer	7
14	S05	D013	5. Dec. 2015	K. Dangol	42	Famer and Carpenter	5
15	S08	D010	5. Dec. 2015	S. K. Dangol	48	Office worker, grocery shop owner	5
16	N04	A015	5. Dec. 2015	G. Dangol	76	Farmer	6
17	S12-b	-	5. Dec. 2015	D. A. Maharjan	29	Artisan (Metalist)	2
18	N05	A014	6. Dec. 2015	S. L. Dangol	68	Gardener (Florist)	8
19	N14	A006 West part	6. Dec. 2015	G. L. Dangol	46	Farmer and driver	4
20	S13	D006	6. Dec. 2015	S. Maharjan	40	Craft artisan	4
21	N18	A005 East half	6. Dec. 2015	S. B. Maharjan	59	Farmer	5
22	S18	D001	6. Dec. 2015	H. B. Dangol	47	Farmer	5

Buildings located at the backside of the street

Fig. 2-6-2 Investigated houses (Houses marked with are investigated, houses painted in white are surveyed inside)

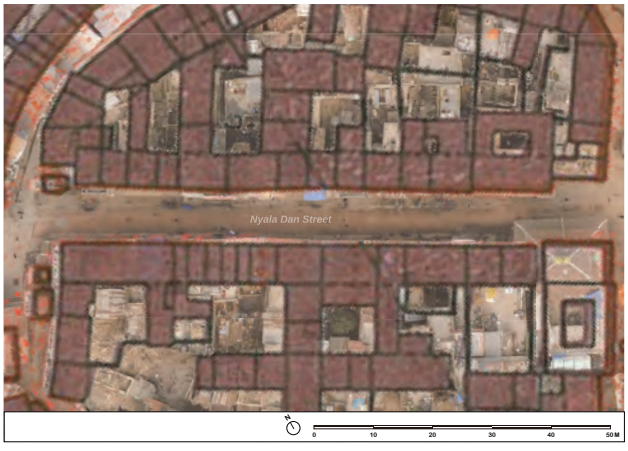


Fig. 2-6-3 Comparison of the map of the year 1969 (Quoted from reference 2) with present condition

courtyards. We were able to recognise the approximate position of houses which were extended or renovated after 1969, although there were some size differences between the plan and the aerial photograph.

We also analysed the transformation of the townscape along Nyala Dan Street based on photographs taken at eye-level. We sourced old photographs data from websites (www.Flicker.com) that we can obtain the date of each photograph and the identity of each photographer, except Fig. 2-6-6. We observed that rebuilding has increased rapidly and the townscape has changed remarkably in recent years, as demonstrated in the attached photographs.

Concerning the landscape in the 2007 photograph, we found that No.7 was rebuilt and the townscape around the street has quite changed from earlier images. However, the harmonic view of the village, with the mountain range in the background, was maintained in the 2007 photograph comparing with 2014 photograph.

In this way, we visually reconstructed the process of the townscape's transformation using the photographs taken at eye-level from the time when digital cameras became widespread until the 2015 disaster.

2. Field survey : History of extension and renovation of houses

In general, it is considered that the townscape of traditional houses along Nyala Dan Street was rehabilitated after the 1934 disaster, then these houses were divided into small narrow houses by repeated property distribution to children or brothers, or transfer to strangers; furthermore, they were also extended or renovated. In this investigation, we clarified through interviews the reasons why the houses and their lots have been segmented and extensions or renovations of those houses have been conducted.

On investigating the transition of each house, we had difficulty establishing the original housing units and their site boundaries if those houses were rebuilt after being divided. Consequently, we examined the shapes of the original houses and compared them with those of the current houses based on the roof shapes identified in the aerial photograph taken in 1973. Incidentally, in addition to the tracings of the original houses noted above, we obtained information about the limits of each original house and its boundary through the interviews.

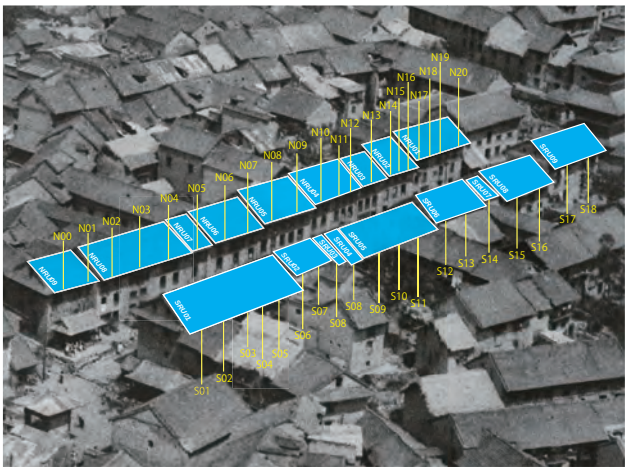
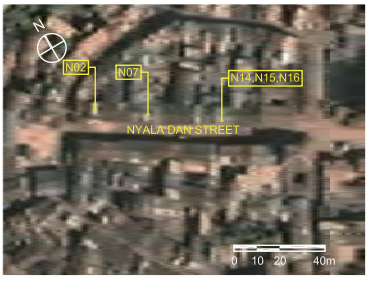
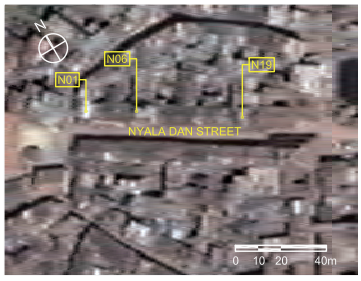


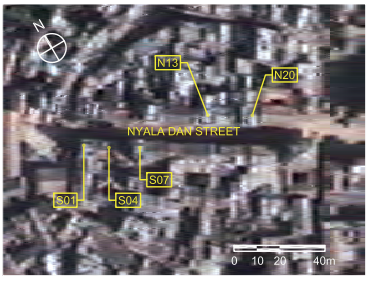
Fig. 2-6-4 Segmentation of the houses by roof shape in 1973 (From reference 1, p.146) with present condition



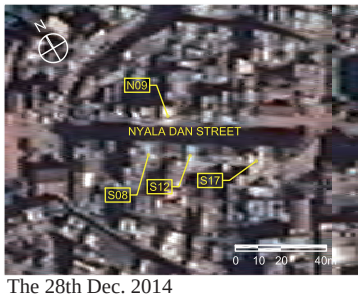
The 21st Oct. 2003



The 22nd Mar. 2007



The 26th Jan. 2010



The 28th Dec. 2014

Fig. 2-6-5 The transition of the aerial photographs of Google map

-The aerial photograph taken in October 2003 is the oldest of those published of the site on Google Earth. At that time, there were only two houses on the street, N02 and N07, which had flat roofs. The incline of the roofs of houses N14, N15, and N16 changed because of extension works. Judging from the roof shapes in the aerial photograph, there are no extension works on the south side of Nyala Dan Street.
-In comparing the aerial photograph (Google Earth map) of 2003 with that of 2007, we see the changes of the roof shapes of N01, N06, and N19 on the northwest side. Conversely, there were no remarkable changes of roof shapes on the south side of the street.
-We see some changes to the roofs of N13, N20, S01, S04, and S07 in the aerial photograph of 2010. At that time, most of roofs of houses at the rear from the street had already been changed from tiled roofs into flat roofs.
-We see that the houses N09, S08, S12, and S17 have been rebuilt and their roofs have been changed in the aerial photograph of 2014, which is the latest one before the 2015 disaster.

Fig. 2-6-6 View from the open space at the west end to the east. This photo was probably taken in the 1990s when the roof of bldg. no.2 changed into the flat one. (source unknown)

Fig. 2-6-7 View from the west end (bldg. S02) to the east, on the 8th January 2005 (photographer: Elke Selter)

Fig. 2-6-8 View from in front of bldg. S17 to the east, on the 14th April 2007 (photographer: Reza Karriem)

Fig. 2-6-9 View from the centre of the street (bldg.S15) to the east, on the 2nd August 2014 (photographer: DNT)

Fig. 2-6-10 View from bldg. No3 to the east, on the 23rd March 2007 (photographer: Gabri+Sil)

Fig. 2-6-11 View from the east (temple) to the southwest, in 2008 (source: unknown)

Fig. 2-6-12 View from the centre of street (bldg.S18) to the east, on the 6th December 2015

Fig. 2-6-13 Chronicle of façades along Nyala Dan street, western district (Chronicle of Extension/Rebuilding)

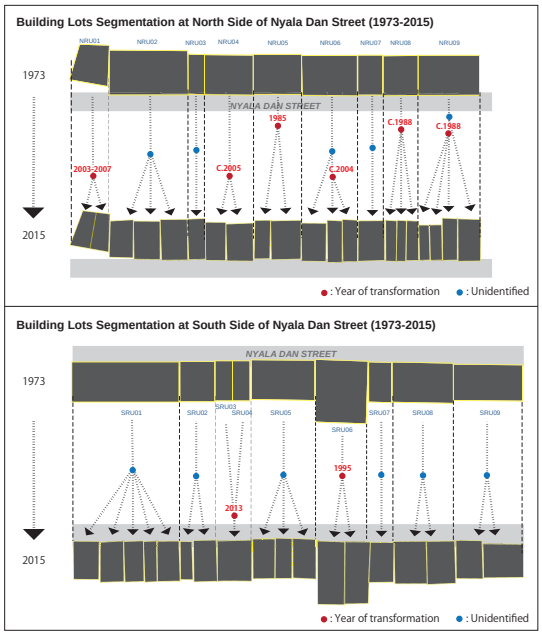


Fig. 2-6-14 Segmentation of housing lots along Nyala Dan street

Number of Building Unit 1973 (*from photograph of 1973, reference 1)	Number of floors (*from photo of '73)	Transition of segmentation pattern of until current architectural forms (cf. commentary of table below)	Number of Building Unit 2015	Number of floors	Year of transformation	Note
NRU01	3	▸ segmentation–unchanged	N00	3	–	Demolished by 2015 EQ
	3	▸ segmentation–extension	N01	4	?(2003–2007)	
NRU02	3	▸ segmentation–extension	N02	4	?(1973–2003)	
		▸ segmentation–unchanging	N03	3	–	
		▸ segmentation–unchanging	N04	3	–	
NRU03	3	▸ unchanging–unchanging	N05	3	–	
NRU04	3	▸ segmentation–rebuilt	N06	4	2005	
		▸ segmentation–rebuilt	N07	4	2005	
NRU05	3	▸ segmentation–extension	N08	3.5	1989	
		▸ segmentation–rebuilt	N09	5	2009	
NRU06	3	▸ segmentation–unchanging	N10	3	–	
		▸ segmentation–unchanging	N11	3	–	
		▸ segmentation–extension	N12	4	2000	
NRU07	3	▸ unchanging–extension–1	N13	4	2007	
NRU08	3	▸ unchanging–extension–2	N14	3.5	1988	
		▸ unchanging–extension–2	N15	3.5	1988	
		▸ unchanging–extension–2	N16	3.5	1988	
NRU09	3	▸ segmentation–unchanging	N17	3	–	3F collapsed by 2015 EQ
		▸ segmentation–unchanging	N18	3	–	3F collapsed by 2015 EQ
		▸ segmentation–extension	N19	4	2008	
		▸ segmentation–extension	N20	3.5	2011	
SRU01	3	▸ segmentation–rebuilt	S01	5	2007	
		▸ segmentation–unchanging	S02	3	–	
		▸ segmentation–extension	S03	3.5	2005	
		▸ segmentation–extension	S04	4	2009	
			S05	3	–	
SRU02	3	▸ segmentation–unchanging	S06	3	–	
		▸ segmentation–rebuilt	S07	5	2005	
SRU03	3	▸ unification–rebuilt	S08	3	2013	
SRU04	3	▸ unification–rebuilt				
SRU05	3	▸ segmentation–unchanging	S09	3	–	
		▸ segmentation–extension	S10	3.5	1971	
		▸ segmentation–extension	S11	3.5	1971	
SRU06	3	▸ segmentation–extension	S12	4	2013	
		▸ segmentation–unchanging	S13	3	–	
SRU07	3	▸ unchanging–unchanging	S14	3	–	
SRU08	3	▸ segmentation–extension	S15	3.5	1985	
		▸ segmentation–extension	S16	3.5	1995	
SRU09	3	▸ segmentation–rebuilt	S17	5	?(2010–2014)	
		▸ segmentation–unchanging	S18	3.5	1988	3F+3.5F collapsed by 2015 EQ

Tab. 2-6-2 Vertical transformation of architectural forms (Building extensions in the horizontal direction are examined separately)

Transformation pattern of architectural forms (Vertical direction only)	
▸ unchanging–unchanging	Without segmentation and extension (unchanging–unchanging)
▸ unchanging–extension–1	Without segmentation, but extended house (unchanging–extension–1)
▸ unchanging–extension–2	Not to segment, but to extend house and to divide interior spaces (unchanging–extension–1)
▸ segmentation–unchanging	Without segmentation, but extended and divided the interior spaces (segmentation –unchanging)
▸ segmentation–extension –1	Segmented and extended the floors with keeping structure of from the ground floor to the second floor (segmentation– extension–1)
▸ segmentation–extension 2	Segmented and extended the floors with keeping structure of from the ground floor to the second floor. Divided interior spaces also. (segmentation–extension–2)
▸ segmentation–rebuilt	Segmented, demolished and rebuilt (segmentation–rebuilt)
▸ unification–rebuilt	Unified the two lots and rebuilt after demolishing small buildings (unification–rebuilt)

Fig. 2-6-13 shows the chronicle of renovation and rebuilding based on the changes of facades along the street, according to interviews with local residents. Concerning the extension period, we roughly divided it into four periods according to the social, economic, and technical tendencies: the first period is from the 1934 disaster until 1972, the second is from 1973 to 2003, the third is from 2004 to the 2015 disaster, and the fourth is from that disaster until now. The extensions and renovations before 2003 (marked in green and red: Building nos. S10, S11, S15, S16, N02, N08, N12, N14, N15, and N16) are identified as small scale, from three storeys to three and a half storeys (to extend the height of the third floor) or four storeys (to add the flat roof); conversely, those conducted after 2004 (marked in violet) are identified as rebuilding on a large scale and demolishing existing houses. After rebuilding, the houses are three to five storeys with a staircase on the top, but the height of each floor is larger; therefore, the houses total heights are much higher than those of the traditional houses. The rebuilt houses have flat roofs and the set back penthouses are built there. Furthermore, water storage tanks have been placed in many of those penthouses.

Fig. 2-6-14 shows the transformation of housing units (SRU and NRU), each of which is considered as one unit, by examining the aerial photograph of 1973. Most transformation cases show that the houses are divided vertically and then extended or renovated. Another case also shows that two housing lots (SRU03 and SRU04) were unified and then a new house (S08) was constructed there. We see only one case in which small lots were unified on this investigation site. However, it is possible that more housing lots will see several small lots being unified in the future. Consequently, it is necessary not only to restrain the segmentation of building lots but also to lead several small lots together to establish appropriate building lots.

(3) Transformation of houses and its factors

1. Spatial transformation corresponding to the change of use of rooms on each floor

In the preceding section, we examined the segmentation and extension of houses to accommodate separate living of households. In this section, we examine the relation of changes of spatial

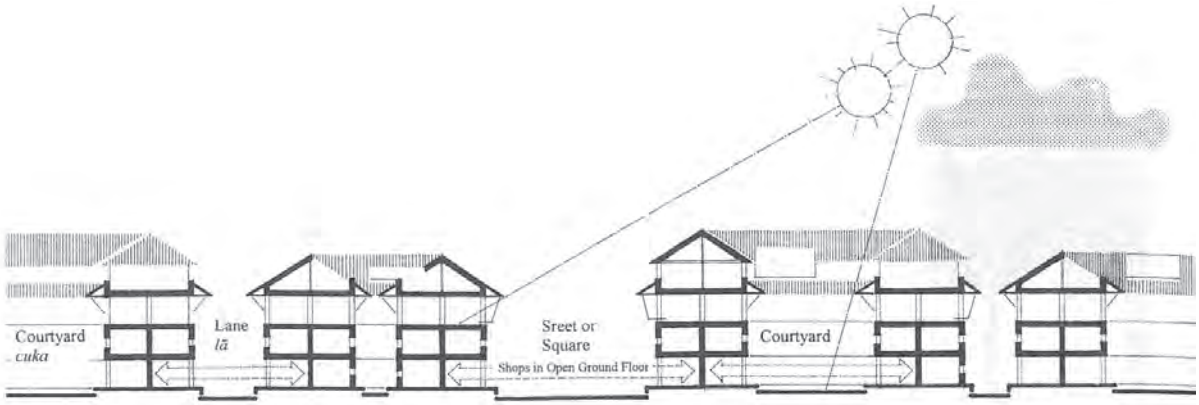


Fig. 2-6-15 Characteristic arrangement of Newal architecture (Drawing G.Auer, 1972) (Quoted from reference 1)

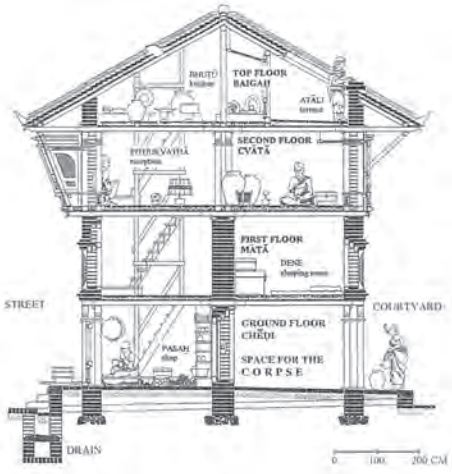


Fig. 2-6-16 Section of Newari house(Drawing G.Auer, 1972) (Quoted from reference 1)

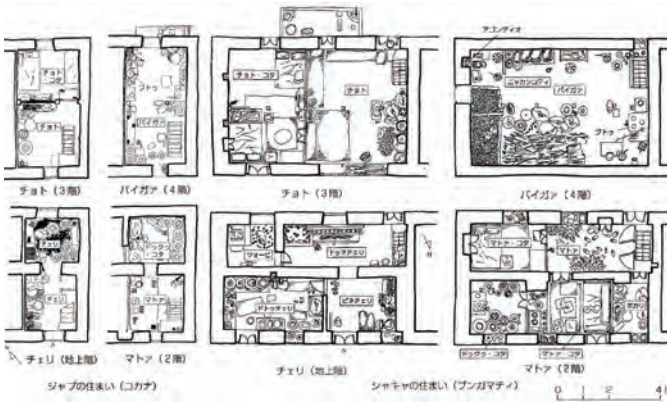


Fig. 2-6-17 Life style of Newari people (Quoted from reference 5)

use inside the house to spatial transformation. We conducted interviews on the use of each room, but it was possible neither to conduct detailed investigation of the spatial use, nor to take detailed measurements inside the buildings. Concerning the Newari traditional house, we assumed the spatial image at the time of the construction, with reference to the writings of N. Gutschow[1] and R. Ranjitkar[4] and the papers of Prajapati and Ms.Taniuchi [5.6.7].

Regarding the basic use of the general house in Newari style, the workshop, warehouse, and animal shed are situated on the ground floor, living spaces are on the first floor and the second floor, and the kitchen is situated in an attic. Concerning spatial use, that of the kitchen and the lavatory has rather changed.

2. Spatial changes of Kitchen

Regarding the spatial expansion of the kitchen, there are lots of cases of the floor height of the third floor being raised or expansion of the floor (N14); in both cases, the houses' facades change. As kitchen utensils have recently become used for discharging smokes (as cassette cooker), we observed that some houses have installed small kitchens on the second floor. Even in the new high-rise houses, there are kitchens and watering places on the top floors like those in traditional houses, and residents occupying the same buildings share these rooms (S01).

3. Additional installation of lavatories

There were some cases in 1990 that lavatories were installed on the ground floor under the staircases (N14, and others). Furthermore, there were common lavatories in the houses (e.g. S03) which different households shared because it was inefficient to install one in each household. In 2003 (around 12 years ago), there were some cases of lavatories being installed in the courtyard with the support of World Vision (e.g. S15).

4. Common use of passages

Along with the extension of houses, we see some spaces (workshops, animal sheds, and others) in the first floor were shared more with several households as through passages to the houses of inner part (S05, N16). We also saw the rooms whose spatial usage changed even though whose main use didn't.

5. Changes from tiled roofs to flat roofs

Some outdoor uses brought inside of the houses have influenced the spatial changes of the townscape. As the main industry of Khokana has been agriculture, it has needed sunny and flat spaces for drying cereals. These spaces are called 'layebo' in the Newari language and are very important to village life. The residents living on the north side of the street use spaces facing the street in front of their houses. Conversely, those living on the south side (as we see at the rear of S14) use the sunny courtyard located on the south side as a workspace for drying cereals because the street side of their houses does not receive much sunshine. However, over recent years their courtyards (as spaces for drying) have become significantly smaller with the extension of housing. The reason to install a rooftop floor (that is, to change from a sloped tiled roof to a flat roof) is the need for more workspace, substituting for the shrinking courtyards. It is considered that the tendency of having flat roofs is influenced by the necessity of access to consistent sunlight, as an alternative to using the sunny courtyards for drying cereal and washing clothes, and providing a suitable position for water tanks on top of the houses In fact, all new high-rise houses in the village have flat roofs. Incidentally, the more they construct high-rise houses, the more residents living around them have to rebuild because they need to retain sunny spaces for themselves. Moreover, one of the factors behind the widespread change to flat roofs is that they probably need personal spaces for each family to use, rather than outside common spaces, to reflect the change from extended families to nuclear families.

6. Other cases of renovation

Although we cannot identify it as a common characteristic, there are various renovation cases due to the necessity of life. In the case of Building S11, engraved pillars, which are very important elements for the historical succession of traditional house, are reused without documentation at different position. We need to investigate this matter in detail in near future.

(4) Transition of housing arrangements

Although each courtyard has its own boundary, they have typically been used as a semi-public space. This space, though, has become smaller gradually from 1934 to the present day because of extensions and rebuilding around them. Most of the courtyards simply became storage spaces for materials after the 2015 disaster.

The through passage which leads from the main street to the rear is a very important urban space not only in Khokana but

Fig. 2-6-18 Façade of traditional house maintained (N05)

Fig. 2-6-19 Extension of kitchen in traditional house (façade of N14)

Fig. 2-6-20 Common kitchen is always installed on the top floor (left back) (S01)

Fig. 2-6-21 Installation of cooking stove on the 2nd floor (N19)

Fig. 2-6-22 Installation of common lavatory in the courtyard (S15, rear side)

Fig. 2-6-23 They drying cereals on street in front of sunny northern house (Outside of the investigation site)

Fig. 2-6-24 Drying cereals in the sun on the roof floor (N13)

also throughout towns in the Kathmandu Valley. As shown by Building N07, the through passage ("Galli" in Newari) is installed again even though houses on both sides of it have been rebuilt. Furthermore, there are common spaces in wellhole style. (void space called "Dhalipwa" in Newari), used as drainage spaces for rainwater and the water from life activities, between neighbouring houses. According to the interviews, there are some unwritten rules stipulating that those spaces need to be maintained even when the houses are rebuilt. These rules are still respected at present: for example, there is a common well left at the courtyard at the rear of building N08. This report has already indicated that the number of courtyards in the investigated site has been decreasing remarkably in this decade. Fig. 2-6-25 shows, in chronological order, the transformation of outside spaces including courtyards caused by extensions and rebuilding.

There are several through passages leading to courtyards or houses behind streets in the investigated site. Each of them has different uses or conditions. As the doors to some of these passages were locked, we could not investigate all of them. However, we show some of the passages that we were able to investigate as they are important factors for examining the future spatial structure of Khokana (Fig. 2-6-26, 27).

(5) Extensions due to the increasing number of people in households and segmentations of housing lots due to distribution of properties

It was clarified in the interviews that after proprietors' deaths, their extended families are separated by each household and house occupied, resulting in the housing lots being divided. The housing outlines have been changing specially in this century depending on the incomes of each family or ages and jobs of their members and they extend their houses or rebuild especially after the division of households when their children grow up.

For example, we investigated Building N08 to explore segmentation of housing lots caused by separation of the household. First, the interviewee and his cousin divided the original building (NRU05) into N08 and N09 to distribute the property about 30 years ago. They then extended N08 at the rear, adding a lavatory (Ground floor), storage (First floor), and a flat roof as their children grew older. Subsequently, a house for the interviewee's relatives was built in the spacious courtyard of the rear eight years ago. A collective house sharing an entrance for the families of the second son and third son was then built six years ago. As the interviewee's house was seriously damaged by the 2015 earthquake, he now lives in his third son's house.

In summary, the original houses and their lots of 1934 have since been divided due to the separation of every household. This enables us to trace the original unit's transition into the different houses of the present day through this research.

(6) Lifestyle of neighbouring of the relatives

The preceding paragraph shows that the relatives of the interviewees came to neighbour each other through extensions or rebuilding of their own houses. Fig. 2-6-28 illustrates how the relatives live in each household. We can see in this figure that many relatives live closely, though each family has their own house,

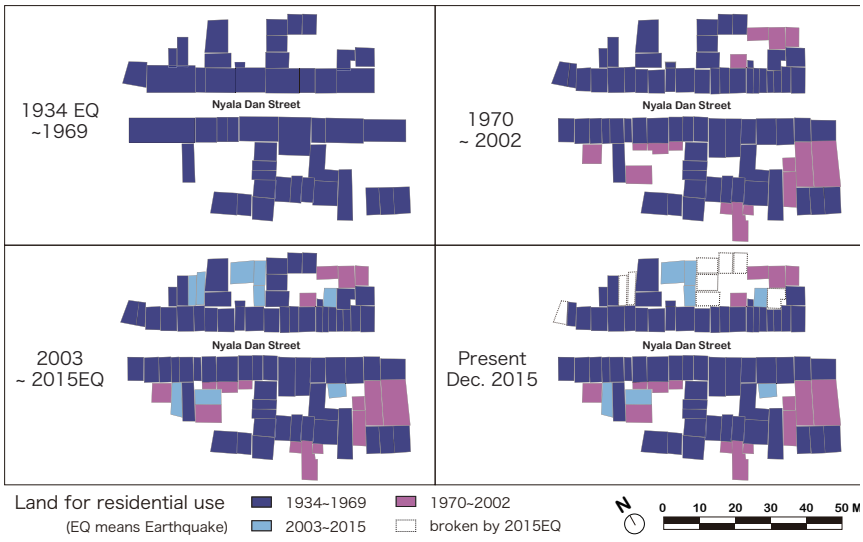


Fig. 2-6-25 Transition of courtyards with extension of housings

as we have seen in the earlier paragraph. In this investigation, it was impossible to conduct a field survey of all the houses along the street and its rear. However, it is necessary to understand the ensemble of such families, houses, and the building lots as those detailed in the earlier paragraph to consider the future rehabilitation plan. We conducted this field survey only along Nyala Dan Street. However, we need to understand the distribution of each Zaat – the base of the Nepal society – in the whole village of Khokana. Therefore, in addition to the perspective of city planning, that of the immaterial culture or ethnological knowledge strongly demands future research.

(7) Conclusion

1. Causes of transformation of the townscape

We grasped the transition of the changing townscape along the target site (Nyala Dan Street) and of block patterns (e.g. courtyards) inside. We then identified the causes of those changes as follows: population increase, changes of family structures, and the division of the extended family by every household (nuclear family, etc.), which has influenced the division of existing houses and properties or the extension and/or renovation of houses. Furthermore, lifestyle changes pressured residents to extend their living spaces, especially the kitchen, and this is another factor in the transformation of the townscape. Further, the changes of spatial use of agricultural facilities (e.g., workshops and animal shed), such as for drying cereals, are related to the changes of the buildings' interior spaces or façades.

2. Housing lots that should be considered as integrated units for rehabilitation of traditional living spaces and their transformation

First, the ownership and management unit of houses or housing lots have changed remarkably since 1934. However, even after the segmentation of housing properties or their rebuilding, the households of the same relatives live closely and they generate living arrangements, such as sharing spaces for agriculture and stock farming. Moreover, as for the outside, there are some unwritten rules concerning sharing spaces with the neighbourhood and maintaining through passages.

The current outlines of houses and lots are quite different from those of 1934; consequently, we cannot surmise their past situation from the present. However, by conducting research interviews, we have been able to deduce the property boundary of each household, the past shape of the buildings or their sites around the common courtyards, and the traditional way of living, such as with relatives. That leads us to consider the units that should be planned together for rehabilitation of traditional living spaces.

References:

1. Gutschow, Neils, Architecture of The Newars: A History of Building Typologies and Details in Nepal; Documentation Drawings by BijayBasukala, Volume 1 • The Early Periods, Serindia Publications, Chicago, 2011
2. His Majesty's Government of Nepal Department of Housing and Physical Planning, The physical Development Plan for The Kathmandu Valley, Published by His Majesty's Government of Nepal Kathmandu, 1969
3. Carl Pruscha, Kathmandu Valley The Preservation of Physical Environment and Cultural Heritage Protective Inventory Vol.1, ANTON SCHROLL
4. Rohit K. Ranjitkar, Kathmandu Heritage Homeowners Handbook 2: Heritage Homeowner's Preservation Manual, UNESCO Bangkok, UNESCO Kathmandu, 2006
5. Prajapati, Ratna Keshari, Mariko Taniuchi and Toshio Shiotani: A study on the spatial concept of Newar people as defined by their way of spatial recognition and behaviour in their dwelling life –In the case of Khokana village and Bungamati village in Kathmandu valley, Nepal, Journal of Architecture and Planning, No.627, pp939-946, Architectural Institute of Japan, 2008.5 (in Japanese)
6. Prajapati, Ratna Keshari, Mariko Taniuchi and Toshio Shiotani: A study on the spatial concept which has created dwellings of Newar people as defined by their behaviour in the ritual and the festival – In the case of Khokana village and Bungamati village in Kathmandu valley. Nepal- Journal of Architecture and Planning, No.631, pp.1861-1868, Architectural Institute of Japan, 2008.9 (in Japanese)
7. Mariko Taniuchi and Toshio Shiotani: Tradition and changes on spatial concepts which has created dwelling houses of Newar people – A case study on Kirtipur in Kathmandu valley, Nepal-, Journal of Architecture and Planning, NO.638, pp.839-846, Architectural Institute of Japan, 2009.4 (in Japanese)
8. Proposition of Khokana Reconstruction and Rehabilitation Committee
9. Yasushi Nozaki: The Role of Indigenous Organization in International Social Welfare – A Case study of Indigenous Organization in Nepal and Cross-cultural Social Work, in: "Nihon Fukushi University bulletin of research – Journal of Culture in our Time", Nihon Fukushi University, Institute for Alternative Systems of Social Welfare and Development, Vol. 112, 2005.8 (in Japanede)
10. Shrestha Rajeeb: Role of local citizens organization to area development – From a case of Guthi in Nepal, "Development, human and local cultures in developing countries", The research project report of the Graduate School of Social Sciences and Humanities, Vol. 215, 2013.7 (in Japanese)

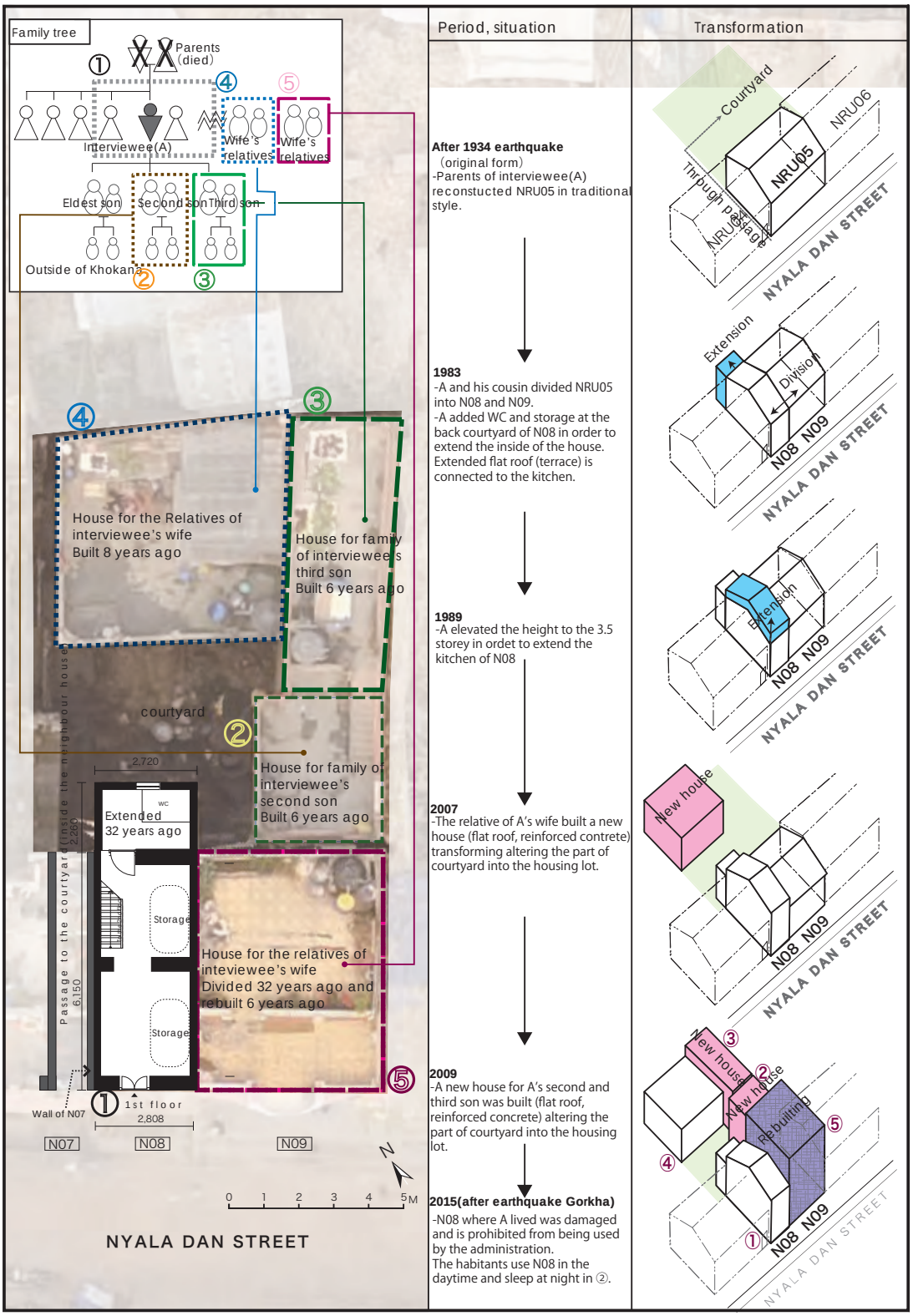


Fig. 2-6-26 Example of segmentation of housing lot by every household (N08)

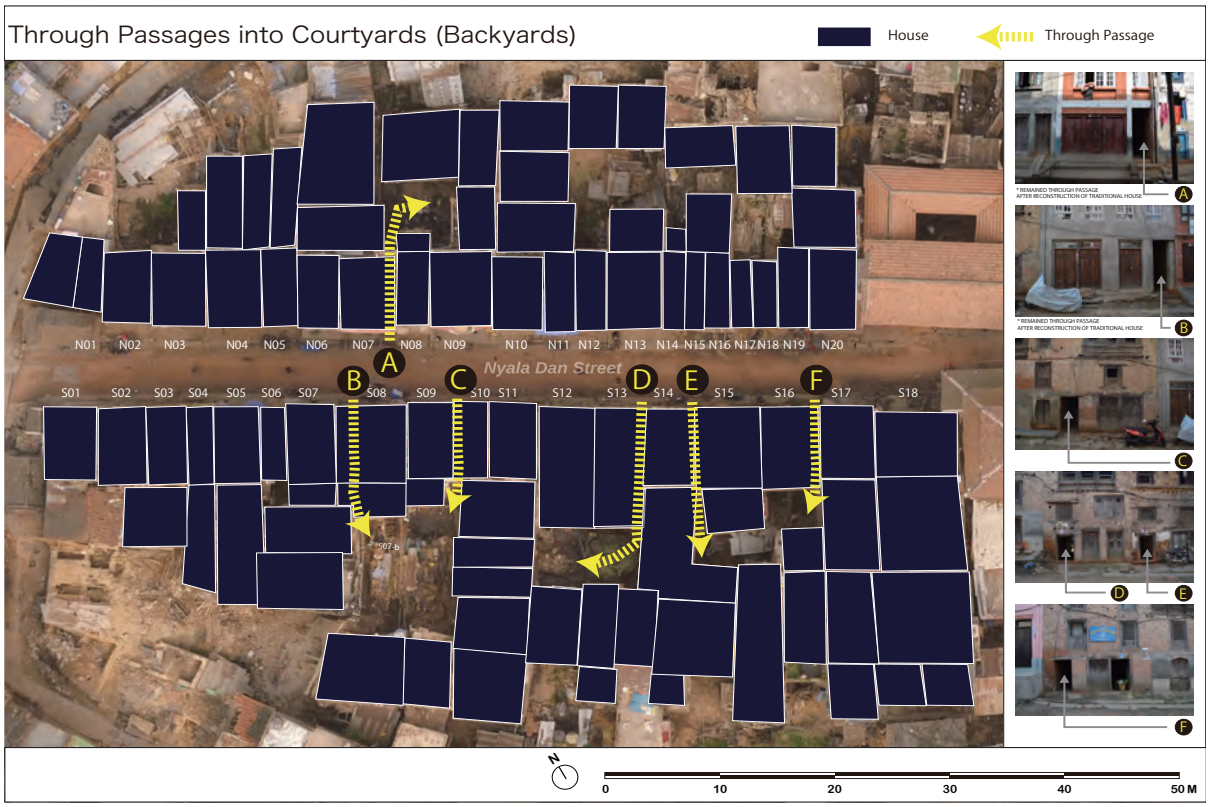


Fig. 2-6-27 Situation of through passage of the inside investigated site

Fig. 2-6-28 Situation of neighbouring of the interviewees' relatives/families (distribution of owners or users of investigated houses)

2.7. Structure of Block

(1) Overview of the survey

Due to increasing populations and other factors, extensions within existing blocks in Khokana continued resulting in overbuilt city blocks. Shared neighbourhood space within blocks gradually became smaller, and issues related to access to sunlight, hygeine and other complications were increasing. With little to no space left, block desnity was at its limit. As a result, blocks were left with disorderly backyard space and extremely narrow courtyards. There was much room for improvement. Through the process of reconstruction after the earthquake, these issues of space within city blocks will be solved by introducing more courtyard space. The purpose of this chapter is to introduce a vision of the future per block or settlement.

(2) Formation mechanism for structure of block

Spaces with blocks in Khokana can be classified into planned Nani courtyard spaces, unplanned Chuka courtyard spaces, and backyard spaces. This analysis will focus on the Chuka courtyard spaces and backyard spaces that make up the majority of Khokana and the process of how they were formed to understand the mechanism of the structure of blocks in Khokana. The proposed rearrangement based on an investigation of the townscape changes was dicussed. Additionally, Using maps and drawings of 1969 Khokana published in Government of Nepal: The physical development plan for the Kathmandu Valley, a comparative analysis of the blocks before and now can be made, and a hypothesis can be proposed for how the structure of blocks was formed.

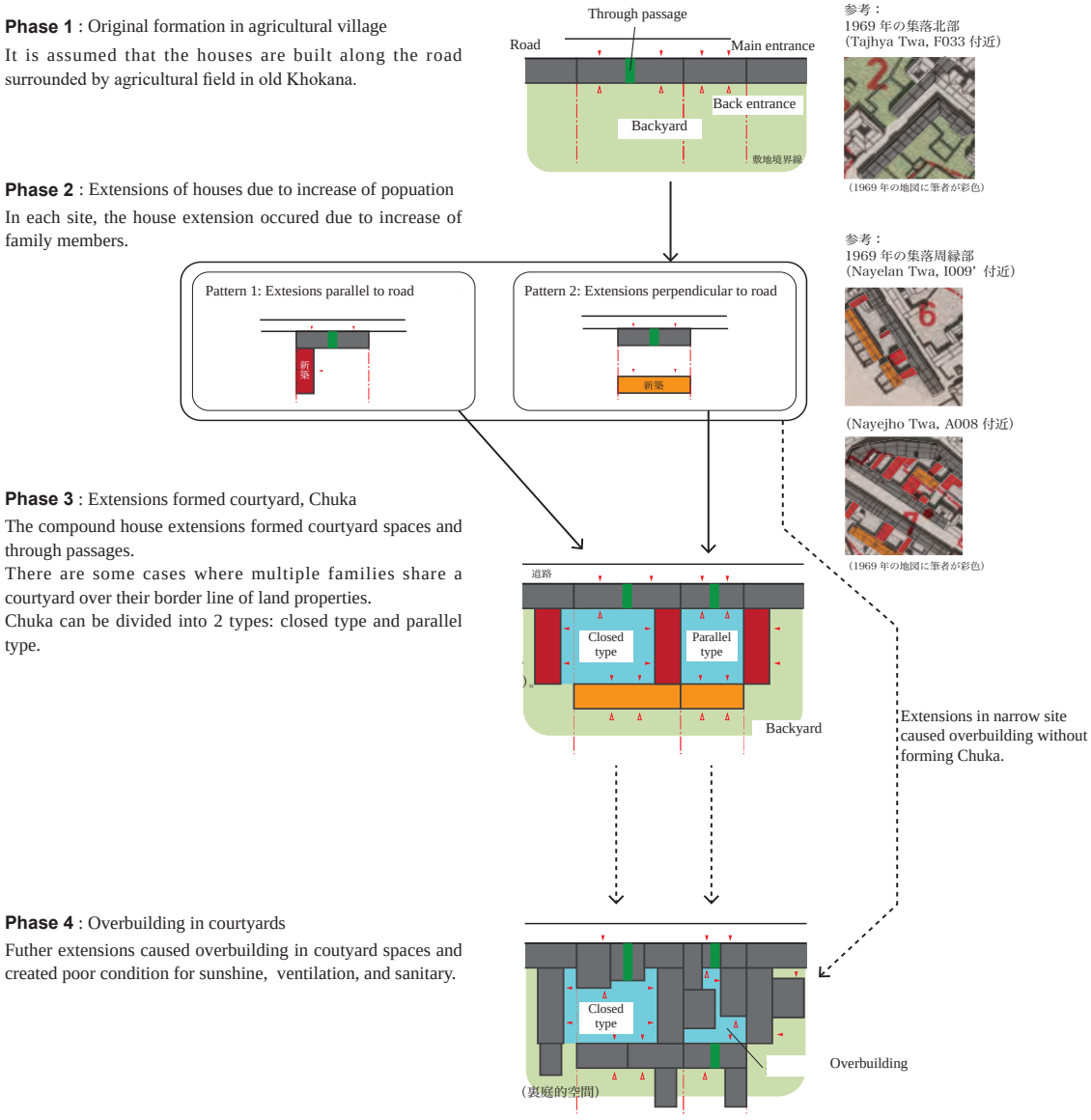


Fig. 2-7-1 Formation mechanism of structure of blocks in Khokana

A proposed hypothetical process has been made based on changes in construction patterns at each site for how extensions were made in Khokana as well as how those additions changed spaces (Fig.2-7-1)

Naturally, not all sites necessarily follow the proposed hypothetical process. There likely are sites that experienced a fourth stage structural addition or more without going through the third stage Chuka construction. Additionally, discerning the Chuka (courtyard space) from backyard space can also be difficult at select sites due to overbuidling. Based on the investigated hypothesis, the location in Khokana where spatial changes are visible at each stage of construction is shown below.

Going forward, this hypothesis will require more investigation of documents, surveys of elderly residents, investigation of site boundries, and more.

As a result of neighbourhood cooperation in Khokana, Nani and Chuka courtyard spaces were made possible. Conversely, recent years have also introduced disorderly extensions, and overbuilding has resulted in spatial shortages and negative effects on the environment among other concerns. To address these issues, we believe that actively including appropriately sized roads and sidestreets into spaces within blocks that have transportation access (Chuka) using examples of efficient courtyard space construction used in Khokana (Nani and Chuka) as a reference to be the most effective solution (Fig.2-7-6).

In this case, however, even if urban courtyards or Nani-esque planned courtyard spaces were to simply be introduced to Khokana, the action risks ignoring the cultural context of the community. The process of how agricultural communities cooperated to create shared courtyard spaces must also be considered.

Fig. 2-7-2 In backyard of F033, there is not much extensions where can be assumed to show original formation of Khokana (Phase 1)

Fig. 2-7-3 In backyard of I009', seen from the the photograph taken in 1969, there were two houses located in parallel (Phase 2), however, in 2016, courtyard are enclosed due to the extension of houses (Phase 3).

Fig. 2-7-4 In backyard of D005, there was a closed courtyard Chuka in 1969, however, in 2016, later extensions caused overbuilding in courtyard space (Phase 3 to 4)

Fig. 2-7-5 In backyard of F053, overbuilding of houses resulted in shortage spaces in courtyard

Rather than planning the courtyard spaces themselves through policy, the better approach would be to set guidelines (minimum courtyard mesurements, etc.) and encourage the formation of shared Chuka courtyard spaces among neighbours. These guidelines would gradually influence construction in this direction after each project. Landowners' rights, site exchanges, reconstruction scheduling, and other factors must be considered when setting these guidelines, so a survey of long-term implications must also be conducted.

(3) Courtyard space scale survey and investigation

1. Outline of the survey

By defining measurements for constructed courtyard spaces in Khokana (Nani and Chuka), changes in courtyard size as a result of overbuilding were understood and consideration of necessary measurements for the creation of environmentally beneficial courtyards was accomplished[1].

According to Wolfgang Korn's THE TRADITIONAL ARCHITECTURE OF THE KATHMANDU VALLEY, the measurements of the planned courtyard (Chowk) within the royal palace located in the urban area are approximately 10m*10m square (Sundari Chowk). Although other courtyards in Khokana and the royal palace's Chowk have many differences including usage and function, existence of plans, and others, its measurements were used as a reference in the comparative analysis of Khokana courtyard spaces. Additionally, the book also states that traditional Newari constructs were 6m long and anywhere from 1.5m to 15m wide although most cases were within the 4m-8m range. The survey was conducted assuming this data to be true. Only accessible courtyard spaces within Khokana (39 total sites) were surveyed. Measurements were made with laser distance measures measuring from the longest and widest areas of the spaces. Length and width measurements were made from wall to wall for buildings enclosing space. For collapsed or demolished buildings, measurements were made up to the point where the pavement changes. Sites without clear measurement points were marked "OPEN" and left unmeasured (3 sites had either unclear length or width measurement points). Height measurements for neighbouring buildings next to select courtyard spaces were taken as well. Furthermore, items left within courtyard spaces, pavement markers, the number of opposite the site, and other visual elements were also noted.

A list of surveyed courtyard spaces is shown in 2-7-10. Buildings with through passages for courtyard access have been assigned an ID number.

2. Survey Results

1) Overview of the results

The average measurements for all 39 sites was 5487mm wide and 6793mm long. (The widest site D009 measures 10700mm. The longest site Dukhachhe Nani measure 15535mm.) A distribution diagram is shown in Fig. 2-7-7.

2) Size of Nani

This section will explain the measurement survey for the 2 Nani sites within Khokana. In terms of width, Dukhachhe Nani measured 10585mm, and Gabu Nani measured 10521mm. Both were approximately 10.5m wide. Conversely, Dukhachhe Nani measured 15535mm long, and Gabu Nani measured 11443mm long. Both sites in Khokana were of similar width with that of the traditional courtyard located within the royal palace of the town area. However, Gabu Nani with its length and square shape of 10-12m, is particularly similar to Newari town courtyards. The measurements for these Nani were larger than all other Chuka measured.

3) Length results and analysis

① Basic length measurements

I009 and I011 are two sites located on blocks on the outskirts of the settlement. It is thought that when extensions were made, the new constructions were built parallel to the original houses lining the road, and the spaces between these buildings became courtyards . The longest measurements for these spaces at I009 and I011 were 10200mm and 10500mm respectively. Both equal at approximately 10m. Considering that there we no blocks or buildings located further out than here, houses in this location could have made efforts to expand their courtyards by moving further away. However, seeing as how both sites measured 10m, one could surmise that these length measurements (approximately 10m) were thought to be the ideal and most natural courtyard size for houses in Khokana. Since these houses both the front and behind the courtyard have 6m long, the composition of houses and courtyard can be seen apprixmately 6m (house), 10m (courtyard), and 6m (house) measured from the front road (Fig.2-7-11). This same 6m-10m-6m measurement structure is used in most other areas of the Khokana settlement according to the 1969 map. Considering the above points, the ideal guideline for Khokana courtyard length can be set at 10m for the present.

Furthermore, two other courtyards had length measurements

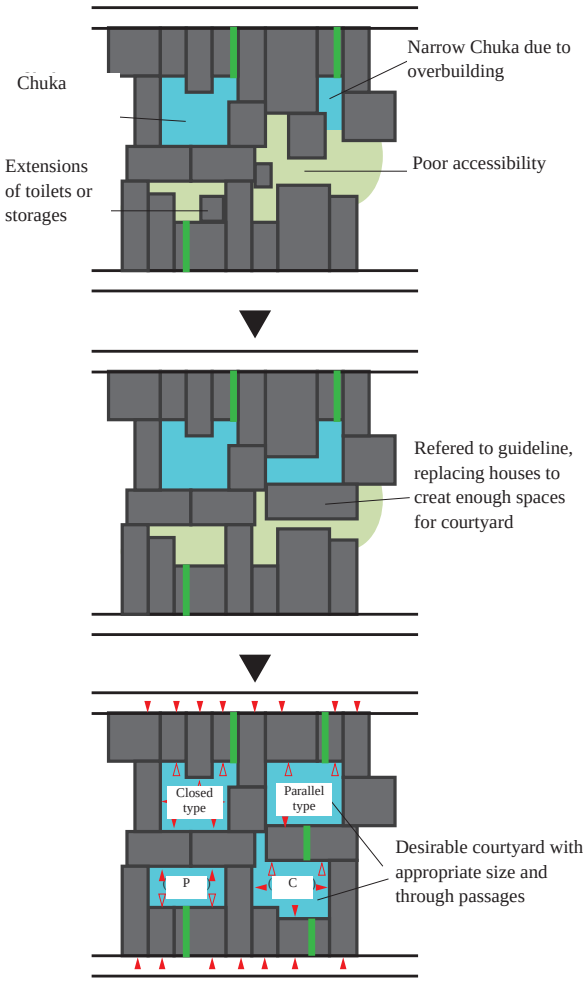


Fig. 2-7-6 Image of guideline for courtyard spaces

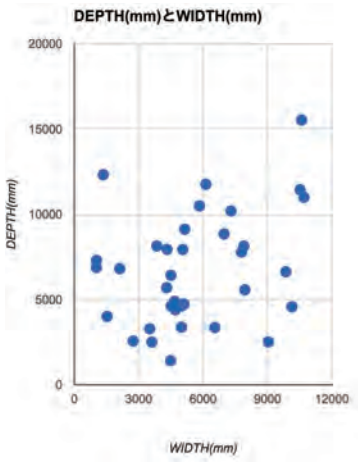


Fig. 2-7-7 Size of courtyard space in Khokana (39 samples)

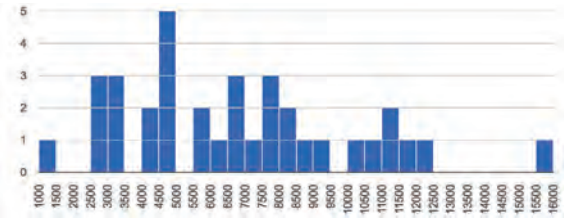


Fig. 2-7-8 Depth of the courtyard spaces in Khokana

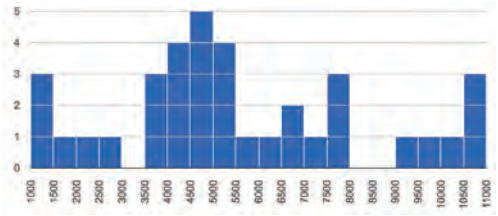


Fig. 2-7-9 Depth of the courtyard spaces in Khokana

Fig. 2-7-10 Location of surveyed courtyards

within 10m±1m based on the actual measurements. They are B064 (9123mm) and D009 (11000mm). 7 of the 36 (19.4%) measured courtyards had lengths of over 10m.

② Addressing overbuilding

Currently, not even the aforementioned I009 courtyard has escaped the influence of overbuilding. The courtyard at I009 extends behind houses I007, I008, and I009. Due to an extension at I008, the length of part of the courtyard is compressed from 10200mm to 5700mm. The growing height of the buildings also limits access to sunlight and negatively affects the environment. Diagram

As shown, in blocks with space shortages and extensions, courtyard spaces that measure less than 10m even at their longest points stand out. Supposing guidelines mandating a 10m minimum length were established, issues in their actual application are likely to arise. Regarding crowded areas where 10m long courtyards cannot be realized, regulations would likely need to be eased to 7m, 8m, 9m, etc. based on the present conditions (There are 7 sites out of the 36 measured that are 10m or longer. Conversely, there are 9 sites 9m or longer, 11 sites 8m or longer, and 15 sites 7m or longer).

③ Addressing variations in house length

Previous traditionally constructed houses measured 6m long. As a result, courtyards are mostly located along this line within blocks (1969 map) Conversely, recent non-raditionally constructed houses mostly measure longer than 6m, so ensuring 10m long courtyards has become difficult.

To address this issue, there is a possible solution that maintains the continuity of courtyards by standardizing back side lines. Using the previously stated 6m (house), 10m (courtyard), 6m (house) measurements as a base, a base line can be set for rear houses (16m from the road) within the block, and houses along the road can be limited to 6-9 meters. Doing so would ensure the courtyard space's length measures 8-10 meters. Given its standardized nature, the method is well suited to long-term planning. For example, combining courtyards would be simpler in the future. Allowing for a 2m extension in the direction of courtyard would result in the below formation. Appropriate extension lengths should be considered with regards to sunlight and other conditions and decided.

4) Width results and analysis

① Investigating ideal width measurements

When searching for examples of wide courtyard spaces, both Nani (10200mm wide and 10500mm wide respectively), D009 (10700mm), and F032 (10132mm) are the widest. All 4 sites fall within the 10-10.7m range. Khokana courtyards are limited to approximately 10m in width as well as length. It can be assumed that this measurement was considered the ideal width as well.

② Setting rules for width

The width of courtyard spaces is highly influenced by the width of the neighbouring houses (and site boundry widths), so applying the ideal size (10m) to all blocks would be difficult. Especially given that traditionally constructed houses using Newari construction methods have a wide variety of widths, guidelines governing courtyard space widths should be flexible for easy implementation. This makes determining the minimum width measurement the core of the policy.

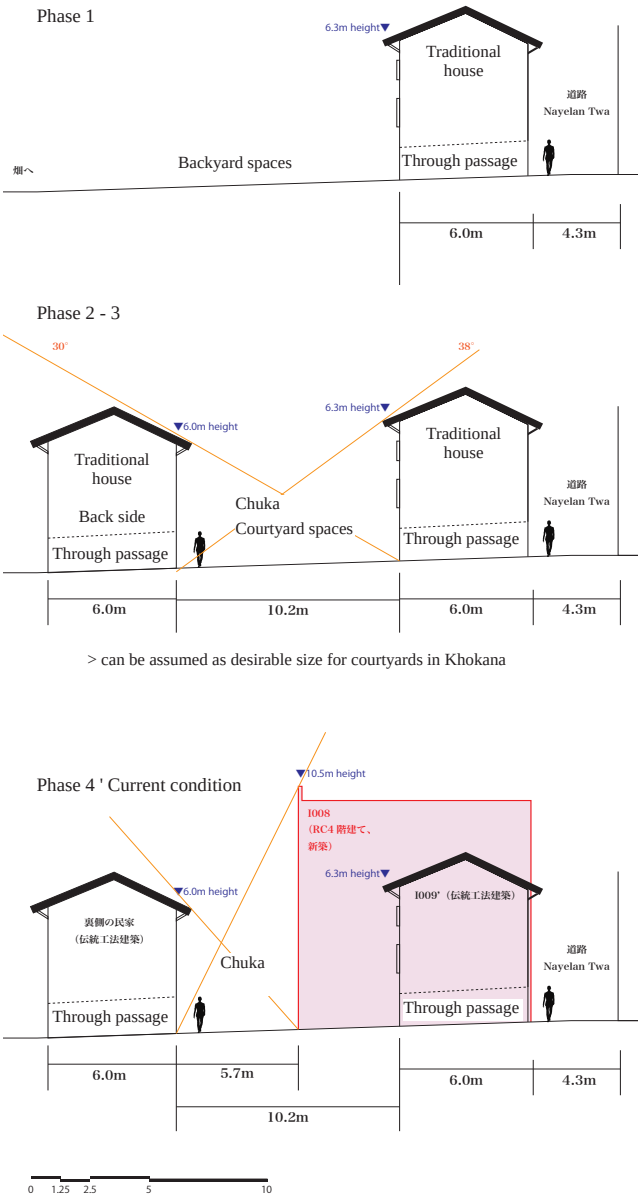


Fig. 2-7-11 Assumed transformation of courtyard spaces of I009

③ Investigating minimum width measurements

Consider now the courtyard space at E017. Its width is a narrow 3843mm, but it is an enclosed type courtyard space surrounded by 2 houses measuring slightly less than 2m wide. Regardless of its narrow width, it is used effectively as a shared space by multiple families. This measurement (4m) could be the basis of the minimum width measurement. Of the sites measured in this survey, 27 of the 36 courtyard spaces had widths of 4m or wider meaning three-fourths of them met this condition.

④ Guidelines for number of houses

In order to effectively use the space within these courtyard spaces, the courtyards themselves should ideally be shared among multiple families. Assuming this to be the case, it is also necessary to increase the number of houses neighbouring these courtyards. Considering courtyard space widths and size guidelines to determine the minimum number of houses beside the courtyard could also be effective. For example, parallel type courtyard spaces (Chuka with only enough frontage for houses on the road side and back side) tend to only be used by one family and their relatives. By defining guidelines requiring the width of these parallel type courtyards to be equal to at least the width of two houses in that location = courtyard will include 2 houses or similar conditions, courtyards can be connected to new houses. As a result, this will introduce courtyards as a communal space that exceeds site boundries.

While House widths range widely from 1.5-15m, setting the guidelines at “2 houses”, for example, would practically requirement measurements that appropriately conform with the space.

Conversely, for enclosed type courtyards, given that they are already surrounded on four sides by multiple houses, these guidelines should not be necessary.

(4) Survey of through passages

Current through passages have been comprehensively mapped (Fig.2-7-12). These maps will serve as the basis for future block design. It will also serve as a clue for discovering how the Khokana settlement came to be.

All through passages in Khokana were visited and had their locations recorded. Furthermore, for the purposes of this survey, “through passages” were defined as passages without doors or those with doors that were always open to allow for access at any time. Additionally, in locations where buildings had collapsed due to the earthquake, local residents were interviewed about any through passages, and the locations of past through passages were recorded.

In areas with many through passages, there was approximately 1 passage for every two houses. Conversely, in the settlement’s comparatively newer, expanded northern district (Gabu Twa North District) there are no through passages. In areas where house density has not increased, it is understandable that the creation of courtyard spaces or through passages is not possible.

Note:

1. This survey drew ideas from Wolfgang Korn and was conducted in meters. Fundamental units of size like this could have roots in ancient units of measurement. This warrants further investigation.

Fig. 2-7-12 Through passages in Khokana

3. Town Houses

3. Town Houses

3.1. Traditionally Constructed Houses

3.1.1 Classification of Traditional Houses

The survey of circumstances of the actual houses constructed using traditional methods in Khokana was carried out and their circumstances in order to obtain pointers for the reconstruction of houses using traditional construction. With regards to the structure of the chapter, we shall first learn about the general form of houses in the Newar community from literature, and then gain pointers for the preservation of historic townscapes by classifying traditionally constructed houses in Khokana and gaining a quantitative understanding of the distribution of house types.

(1) Features of traditional houses of the Newar people

1. History

It is thought that the dwellings of the Newar people underwent drastic change around the end of the 19th century in the period that saw a transition in government from the Malla period to the Rana period, with the white-walled neo classical style royal palace that was influenced by the West having a strong impact on house design.

The typical form taken by windows is a lattice window with square wooden frame.The shape of windows started to transform around 200 years ago. Yet while the windows became taller, the lattice over the windows kept the same level of workmanship. In this process of change, the windows came to take on a simple arrangement (Fig.3-1-1).

2. Construction methods

Newar houses are composed of stone or brick foundations, brick walls, floors made from clay, and a wooden structure that supports a tiled roof. It is considered that a brick “spine wall” supports the interior load of the first and second floors, while pillars support the load of the third and fourth floors (Fig.3-1-2). This is generally known as a timber framed brick construction.

The houses have brick walls that are built on top of a brick continuous footing, and beams are placed horizontally at the top edge of external and internal walls. Joists are then laid densely on top of beams between the walls, and floor boards are laid on to which earth is packed to create an earthen floor. An earthen floor, or in other words a flat surface, is created for each floor, and the overall structure is an iteration of a cross section that keeps the same scale.

3. Materials

The intense rainfall (of up to 60mm/h) experienced during the roughly four-month monsoon season in the Kathmandu valley is thought to have determined the materials used in traditional houses. An example of the this is brick and stone, which, being resistant to water, are used in foundations and walls. It can also be argued that the reason that roofs are tiled is because in comparison to thatched roofs, tiles offer better protection against water seeping into the interior of the building. Furthermore, it can also be considered that the roofs are pitched and have long eaves in order to provide shade

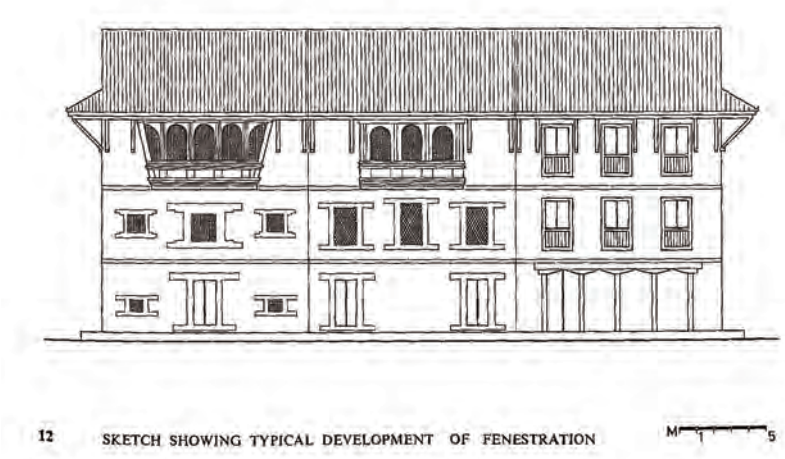


Fig. 3-1-1 Typical development of openings in Newari houses. From left to right, the style goes forward in time. (Quoted from Wolfgang Korn ”The Traditional Architecture of the Kathmandu Valley”)

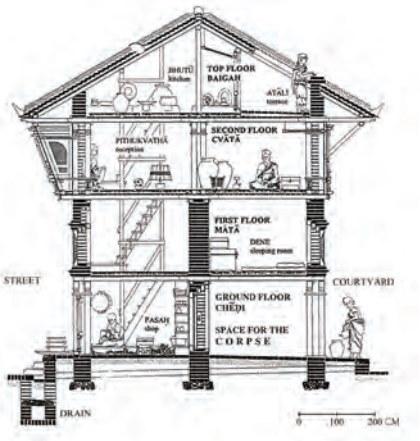


Fig. 3-1-2 Section of traditional newar house (Quoted from "Architecture of Newars")

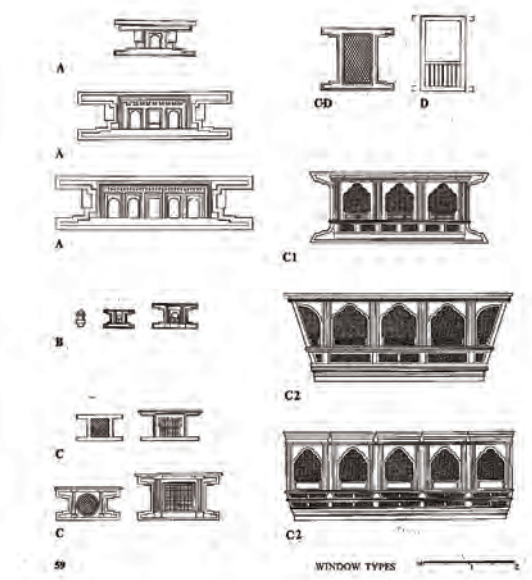


Fig. 3-1-3 Type of windows (”The Traditional Architecture of the Kathmandu Valley”)

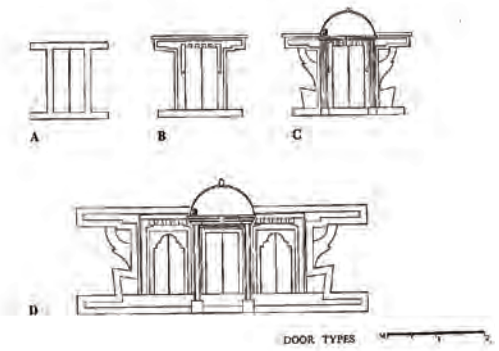


Fig. 3-1-4 Type of doors (”The Traditional Architecture of the Kathmandu Valley”)

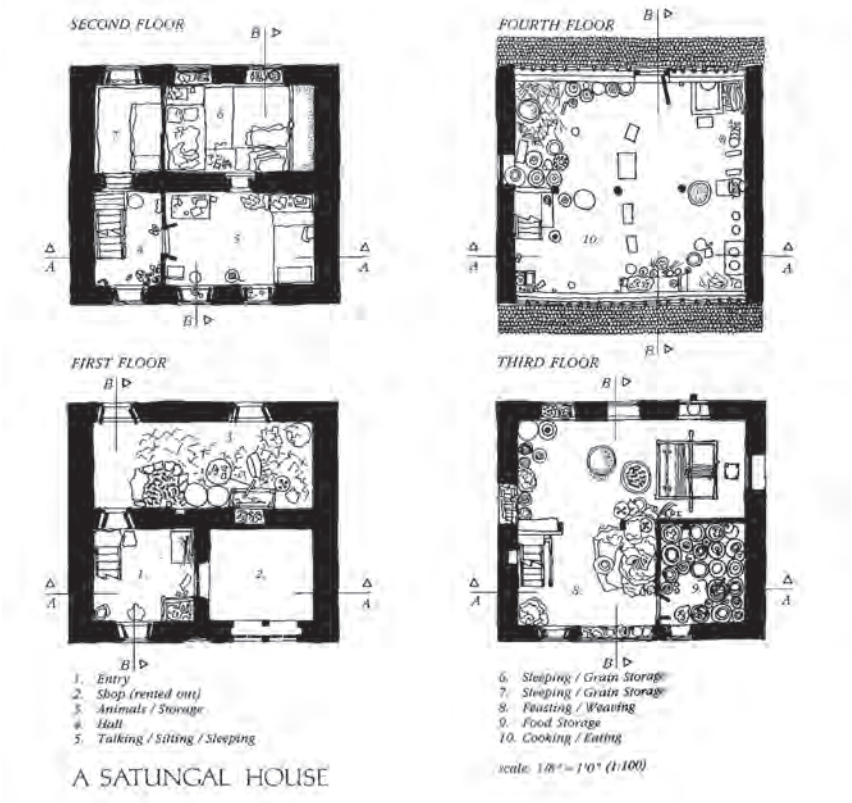


Fig. 3-1-5 Plan of traditional newar house□'Satungal', “4 VILLAGES: ARCHITECTURE IN NEPAL”□

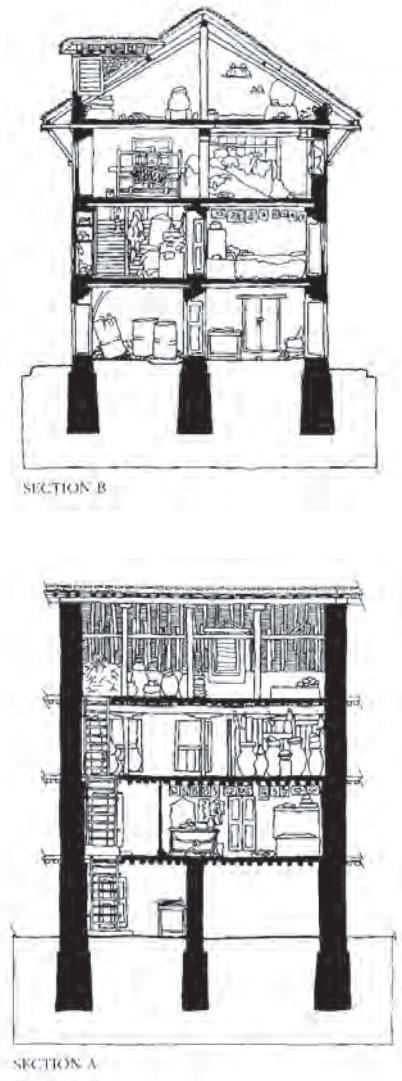


Fig. 3-1-6 Section of traditional newar house ('Satungal', “4 VILLAGES: ARCHITECTURE IN NEPAL”□

and drain away water. As well as this, from the perspective of the risks posed by fire spreading in high density housing, the use of brick walls, tiles, and earth in construction is extremely logical as non of these things are flammable.

Bricks: Both sun-dried bricks and baked bricks are used. Baked bricks look more attractive than sun-dried bricks and are resistant to water, and so these are used for external walls. Cheaper sun-dried bricks are used for internal walls are not exposed to the environment outside the house. Stone is the most water resistant material, however, given the difficulty in obtaining it in the Kathmandu valley it is only used in the foundations.

4. Roof

Roofs are tiled, and are comprised of simple roof trusses composed of posts and rafters. The posts create a gabled roof with a pitch, and the rafters are arranged densely and roof boards laid with packed earth on top to create an earthen roof, so in other words a construction method in which tiles are attached to an argilliferous earthen roof has traditionally been used. The eaves protrude significantly, with an average protrusion of 1m.

5. Openings

Openings take the form of a laterally stretched Roman numeral 'II' with a base and a lintel extended to the left and right of a mullion, and doorways and wooden carved decorative windows are placed in the brick walls.

Furthermore, there are also cases where lattice windows incorporated into things such as balconies, and architectural styles where brick walls are constructed on the courtyard side. After the start of the Rana dynasty in the mid 19th century, openings evolved gradually to become bigger and windows became taller. The openings are small in comparison to the area of the walls.

Windows are the parts of the houses that best showcase the subtle craftsmanship of the Newar people. As shown in Fig.3-1-3, A is a design that is mostly seen in viharas (which are temple buildings). B is a design that has no function as an actual window, and it is used with a decorative nuance. C1 (sanjhya) and C2 (ga jhya) are called triple windows, and as well as the royal palace and temple buildings these forms are also seen in houses. C is a window design that is often incorporated to the side of triple windows, and is composed of a simple wooden frame and lattice. D is the most recent form, and in comparison to A through C it ensures sufficient sunlight and airflow reach the interior. It is only used in houses. As for the dimensions, they are typically 1,500mm in height and 800 - 900mm in width. C-D is a design that integrates the features of the grate in C and the features of D. (Figure 5-1-3) Doors are never larger than 700mm x 1600mm not only in houses but also in monasteries and many temple buildings. The doors themselves are wooden and sturdy, and have a heavy iron lock attached to the interior side. They are composed of an interior frame and an exterior frame, and the type that is used in houses is the simplest one, type A. There are no significant differences in the basic structure, and they can be classified into different types by whether they have decorations or not. (Fig.3-1-4)

(2) Layout and use

The ground floor is divided into two rooms by a bearing wall. In the rainy season, the groundwater level rises and moisture penetrates the foundations. As such, in addition to experiencing very high humidity, the highly dense housing does not let in much sunlight and this results in an extremely poor environment. Thus, actual daily life takes place from the first floor upwards, and in many cases the ground floor is used for storage or a small barn for livestock. It is used as a store by some households, and examples of this can be seen in the Khokana.

As with the ground floor, the first floor is divided into two rooms by a bearing wall. Innermost rooms are further divided into smaller rooms that are used for sleeping or storage in many cases. The room equivalent to the living room is the closest to the road outside, and this is where the family comes together.

The second floor has one large room, and in many cases has pillars. In three-stories houses, this is traditionally used as a banquet room. Considering the overall structure, it is apparent that banquets and meals are very important to the Newar people, who have many festivals and feasts in comparison with other ethnic groups in Nepal. The shrine installed in houses is often found on this floor, but it does not have a particular place and there are some settlements that install it on the first, second, third floor. The place where banquets are held is the one that has the most windows and is the brightest in the house.

As with the second floor, the third floor has one large room that features lines of pillars, and this floor is only used for dining or cooking. Broadly speaking, there are considered to be two reasons for this layout. The first is a cultural reason whereby the kitchen

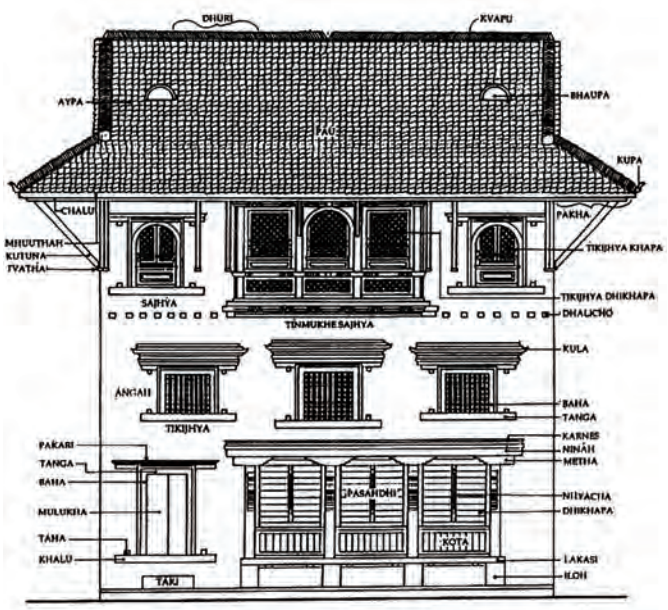


Fig. 3-1-7 Terminology Quoted from "Home Oweners Manual"

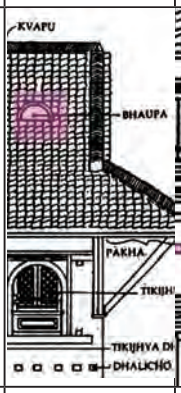
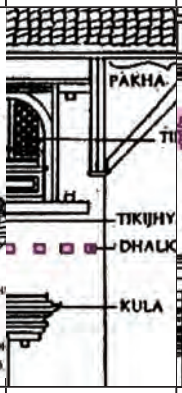
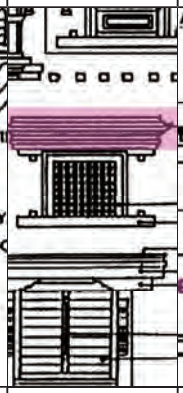
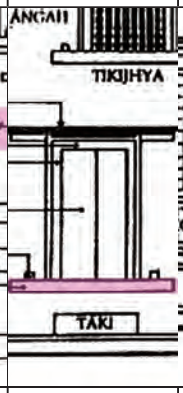
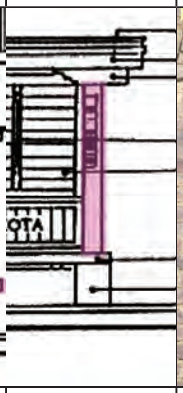
	Elements rarely seen in Khokana	Elements which has similarity to common names			Elements used in Khokana which were not on diagram	Elements used in Khokana which were not on diagram
Common names in Newar settlements	BHAUPA	DHALICHO	KULA	KHALU		
Names used in Khokana		DHALIN	KULAKHU	KOLAKHU	Tha	KHA PWA
Figure						
	Windows for ventilation or Chimney	Cut end of Floor joist	Multiple layer of liner decoration of window frame	Sill of a door	Pillar of openings at the ground floor	A hole on the wall for bird nest

Fig. 3-1-8 Architectural terminology of traditional newar house in Khokana

is located in the most inaccessible place in the house in order to guarantee that lower castes as seen from the perspective of the Newar people (who have a strong caste awareness) and Dalit people cannot enter the kitchen, where normally family members are permitted to enter. The second is a practical reason, because the fourth floor is best suited to getting rid of the smoke from cooking. According to the literature, many households have created roof terraces on the top floor of their house and have halved the space used for cooking and eating. Places such as this mean that crops can be dried in the sun without constant supervision to make sure they aren't eaten by chickens or animals, while at the same time enabling, it is said, woman to prepare meals in the sun[1]. (Fig.3-1-5, 3-1-6)

(3) Architectural terminology

In order to identify regional features of traditionally constructed houses in Khokana, the comparative survey was carried out by collecting the names of architectural elements generally used by the Newar people and those in Khokana. Using a glossary based on literature, we interviewed resident local specialists (Fig.3-1-7). As a result of the survey, local specialists pointed out that there did not appear to be much difference. Furthermore, it was not possible to conduct an interview with a resident who had a comprehensive knowledge of the names of architectural elements. As well as responses for elements saying that while they knew the name they aren't seen in the Khokana community (bhaupa: chimney window), we also found parts with names that are similar to common names (dhalicho/dhalin), (kula/kulakhu), and (khalu\kolakhu), parts that did not have a name on the diagram but for which we received an answer (tha), and parts that were not on the diagram but that exist (kha pwa) (Fig.3-1-8).

Of particular note, a kha pwa is a hole in a wall that is created by removing some bricks, and we saw it in several houses.

We were unable to check in comparison to general Newar houses, and we discovered that there were simplified parts and names peculiar to different regions. Also, given the fact that there are names that are not noted on general houses, it can be inferred that for the residences there is some kind of cultural significance. It can be considered that going forward a survey and consideration of the regional features of Khokana based on a comparison of houses with other communities is needed.

(4) Classification of house facades

In order to identify the features of townscapes and houses for the purposes of creating design guidelines and to understand the design of facades in traditional houses in the Khokana (southern residential zone), we carried out a detailed survey of the important elements of roofs, braces, tiles and wooden carved windows in houses built using traditional construction methods.

In this survey, we recorded the architectural elements of traditionally constructed buildings in an illustration book, while at the same time measuring and recording the length of the eaves and the roof pitch. The subject of the survey was the 18 traditionally constructed buildings facing the main street (nyaja dan twa) before the temple that had kept its townscape with traditional houses after the earthquake in the Khokana community (southern residential zone) (Fig.3-1-9). In addition to the elements based on classifications in the literature, the elements judged as being important in terms of townscape scenery (materials, roof, openings, windows, doors, rough outline of the houses and wall positions, braces, decorations)had set forth.

1. Townscape

Every house in the survey was gabled and had an entrance on the side which runs parallel to the front road The wall position is the same as the adjacent building, and this forms the townscape.

2. Facade

It was found that all houses in the survey used bricks, but there were seven houses that used cement or mortar only on the ground floor. There was only one house that was completely painted. Furthermore, the white walls seen in the royal palace were not seen in traditional houses which were the subjects of the survey (Fig. 3-1-10). Of the 18 houses, there were 15 in which shows dhalicho (cut end of joists) on the facade.

Fig. 3-1-9 Target area of the survey

3. Roof

13 of the 18 houses in the survey used tiles, for which the supply has increased recently, or tiles that are used in temples within the Khokana community. Due to the earthquake, there were also houses that made use of relatively cheap junk metal, or corrugated iron. It was seen that in all roofs that used tiles, a joint style was used - or in other words a construction method that doesn't use earth (Fig.3-1-10). The average length of the eave protrusion was 1089mm, which was almost the same as the one meter noted in the literature (*Wolfgang Korn "The Traditional Architecture of the Kathmandu Valley", 1976, University Press of Tribhuvan) (median value).

14 of the 18 houses had a pitched roof. Rafters were seen in all of the houses in the survey. The rafters tended to increase in proportion with the size of the frontage (positive correlation) (Fig.3-1-11).

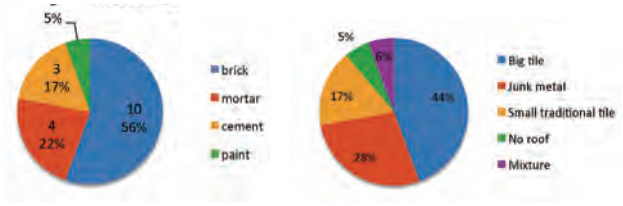


Fig. 3-1-10 Wall material of GF (Left), Roof material (right)

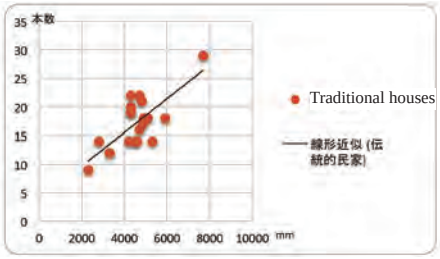


Fig. 3-1-11 Relation between frontage width and number of rafters

4. Openings

The openings from the first floor upward in 16 of the 18 houses in the survey were axisymmetric along the vertical axis with the ground. Line symmetry is deemed an important element of traditional houses, but one house that is thought to have been divided in the process of inheritance was seen and one house with modern window designs on the second floor was also seen (Fig.3-1-12).

Fig. 3-1-12 Subdivision of the house cause the lost axisymmetry (Left), the example of replacement to the modern style window (right)

Broadly speaking, the windows on the first floor and above have vertical to horizontal ratios of around 1/1 and 5/3. The former is a very old style. There were more than 10 houses with more modern tall openings (Fig.3-1-13).

In contrast to the openings on the first floor and above, most of the buildings had openings on the ground floor that were not axisymmetric in their location. Furthermore, none of the traditional houses that we surveyed had windows in the ground floor.

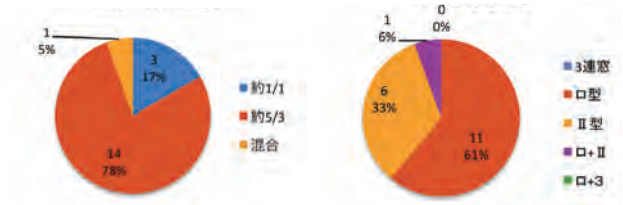


Fig. 3-1-13 Ratio of window frame (left), Style of window frame (Right)

5. Braces

53.57% of the window height way up the bottom part of window frames on the second floor is a brace base (sample of 15 houses, median value 50%).

In terms of a pattern for the location of brace bases horizontally, regularity was observed in the way that vertically their position followed the second floor window frames while others where located at both edges of the building (for triple windows, there are four and they follow the window openings) (Fig.3-1-14). There were

Fig. 3-1-14 Pattern for location of braces according to style and number of windows

very few houses that featured carvings which were geometrically simple. (two out of 18).

6. Window frames/windows

The shape of the windows on the upper and lower sections can largely be divided into “II type” windows that resemble a horizontally stretched Roman numeral II and standard square type windows. The former is a much older design.

Almost all windows on the second floor are square type, whereas on the first floor the ratio of older II type windows is higher, with six II type windows and 11 square type windows being seen (Fig.3-1-15).

In the case of square type windows on the first floor, the number of openings with a 5:3 ratio was 100%, and the breakdown of the design of the windows in the openings is nine wooden doors on hinges and two lattice windows. There were also two cases where the window frame was an II type and the ratio of the opening was 5:3. There were three cases where the window frame was an II type and the ratio of the opening was 1:1.

Of the 18 houses surveyed, six had the wooden carved triple windows that are a significant feature of Newar architecture. All of these were bay windows. No windows with a lattice were seen on the second floor.

There were two patterns observed for lattices, either 90 degrees or at an angle of between 45 and 60 degrees (Fig.3-1-16). Regarding the latter, some kinds of simple carvings were observed.

7. Ground floor openings (doors)

There were seven buildings that had doors with a design where the top and bottom beams did not appear in the facade. There were seven buildings that had doors featuring a design with elements called twaka in a II type frame. We took actual measurements for a total of 10 windows, doors, and other such things (Fig. 3-1-17).

8. Decorations

Some of the houses had been influenced by western architecture, and featured decorations such as cornices or decorative pillars. Of the 18 houses, four had cornices and one had decorative pillars.

The design of the cornices was not like the intricate carvings featuring snakes, flowers and grass as seen in the Newar temples, and using bricks with altered heights or curved surfaces, most of these cornices were created by simply actions such as rotating the angle of the bricks that form the basic building units by 45 degrees.

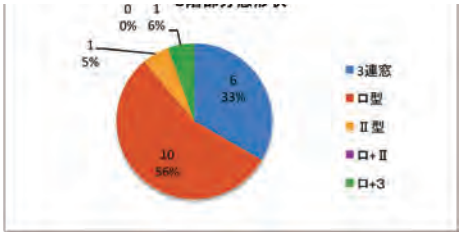


Fig. 3-1-15 Window style of second floor


Fig. 3-1-16 Examples of lattice window. There are some curving on the lattices (Right).

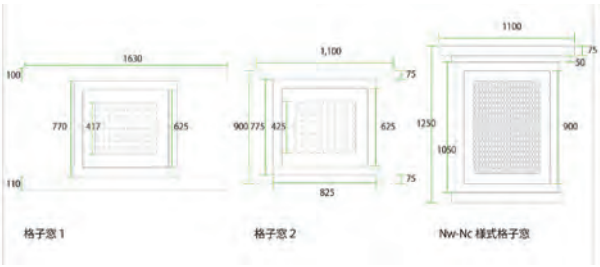


Fig. 3-1-17 Measurement of windows

The following are the features that were almost entirely shared by the houses in the survey.

・Gabled with an entrance on the side which runs parallel to the front road.

・Had openings positioned to be axisymmetric.

・Pitched roof with rafters on display.

・Braces from more or less the center of the window frames on the second floor to the eaves on the pitched roof.

・Exterior walls with no paint from the ground floor upward built of brick masonry with clear masonry joints.

It is thought that the facades of houses in Khokana created using traditional construction methods can broadly be grouped into three types regardless of whether an extension has been built on the top floor (Fig.3-1-18).

Type 1

This is the most traditional type and has the features of the Malla period, with a 1:1 ratio for the openings, II type window frames, lattices, and triple windows.

Type 2

This type combines features from both the Malla period (II type window frames and lattices), with an opening ratio of 5:3 but a II type shape or an opening ratio of 5:3 and a square type shape but covered with a lattice, and the Rana period onward (opening ratio of 5:3 and a square type window frame),

Type 3

This type has an opening ratio of 5:3 and square type windows, and incorporates neoclassical decoration in the form of cornices and decorative pillars.

In addition to the features above, we also observed several houses that had triples windows on the second floor.

On the basis of the results of this survey, in the report we refer to the features seen in Type 1 as Newar elements and those seen in Type 3 as neoclassical elements.

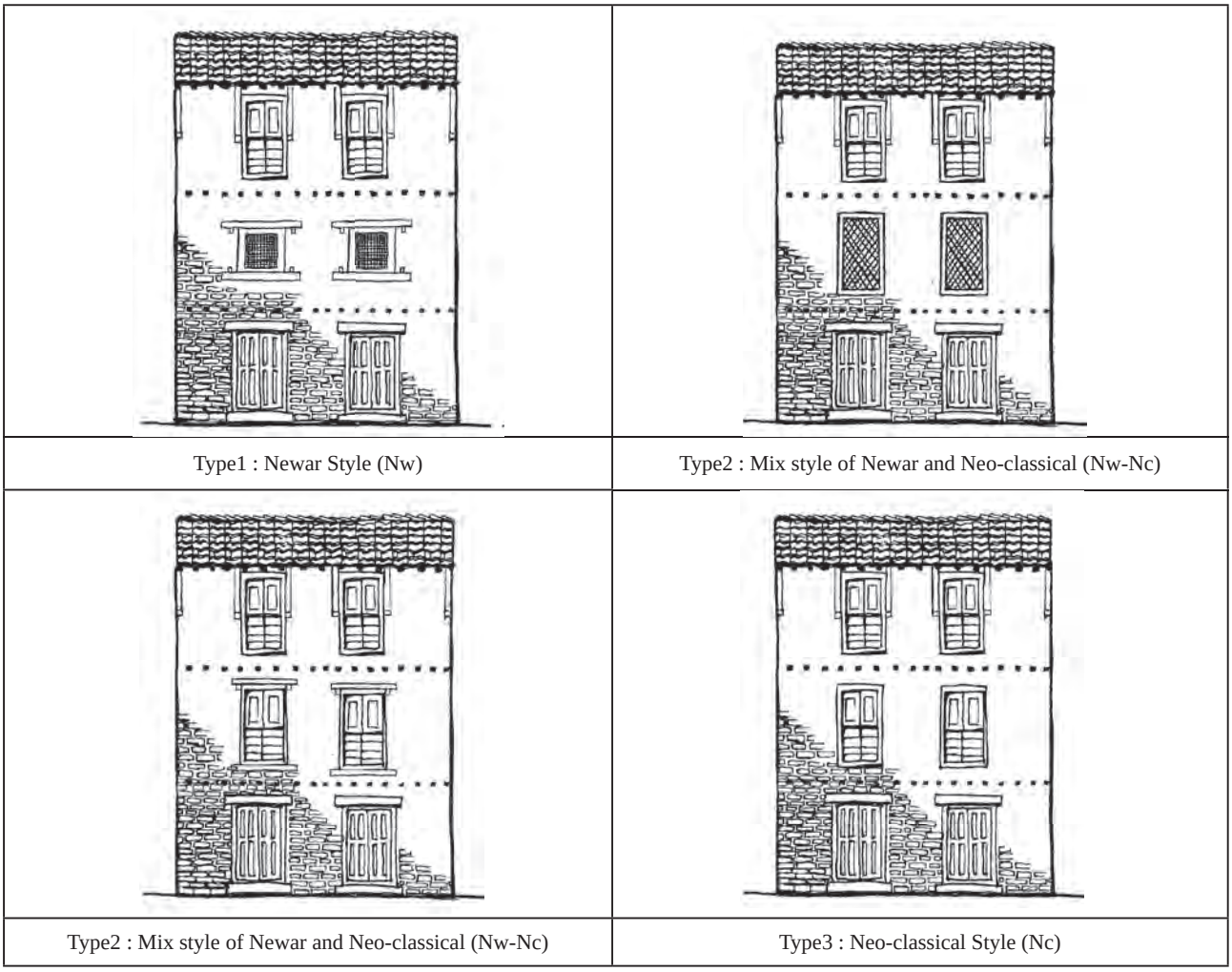


Fig. 3-1-18 Facade type of traditional houses

(5) Distribution of housing types based on traditional construction methods

With the goal of increasing the practicality of creating and implementing design guidelines for buildings based on traditional construction methods, we attempted to gain an understanding of the design of the facades with the features of traditional buildings by focusing on houses based on traditional construction methods in Khokana.

We categorized them into the three types of houses: facades with Newar elements (Nw), neoclassical facades in which Newar elements can be seen (Nw-Nc), and facades with neoclassical elements from the Rana period onward (Nc), as well as those that have no specific features and those whose style cannot be determined due to only having one floor (GF).

Facades were mainly surveyed visually. Determinations were also made using photographs. Of the structural complexes determined to be buildings based on traditional construction methods in a 2015 survey, the scope of this survey covered traditional buildings (main buildings) from phase 0 to phase 2 of the survey conducted to gain an understanding of the changes in these buildings and the current way they are used. Due to time restrictions in the survey, we focused on traditional buildings facing the street from the standpoint of preservation of the townscape.

Determination of style was performed based on the procedures and standards in the figure below.

・Nw-Nc refers to buildings with facade designs that incorporate Nw elements into an Nc style.

・Openings with a size and proportion close to 1:1 were deemed to be Newar elements, and those close to 3:5 were deemed to be neoclassical elements.

・We defined lattice windows as those that are completely covered by lattice, regardless of any angle of intersection in the grating.

・II type windows that are longer horizontally and have sills and lintels that extend to the left and right are deemed to be old designs, and were determined to be Newar elements.

・The presence of triple windows was deemed be a Newar element, and buildings with these were deemed to belong to the Newar style regardless of other criteria.

・The presence of cornices or decorative pillars was deemed to be a neoclassical element, and buildings with these were deemed to belong to the neoclassical style regardless of other criteria (Figure

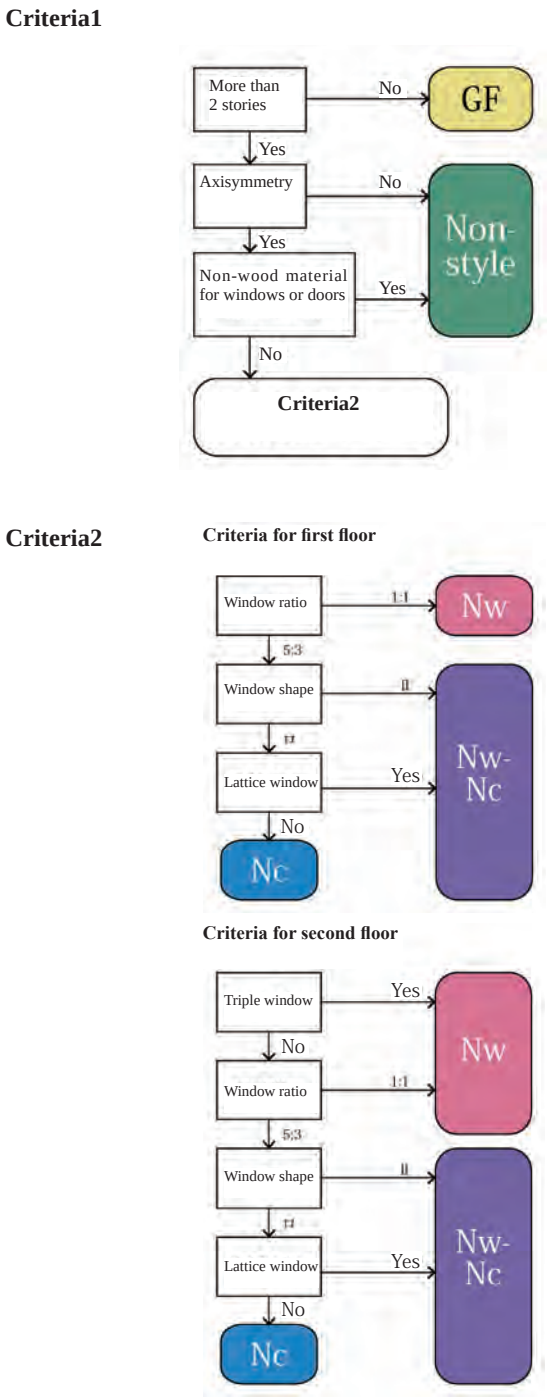


Fig. 3-1-19 Flowchart for determination of style

2F \ 3F	Nw		Nw-Nc	Nc
	With triple window	Without triple window		
Nw	Nw	—	Nw-Nc	Nw-Nc
Nw-Nc	Nw	—	Nw-Nc	Nw-Nc
Nc	Nw	—	Nc	Nc

Fig. 3-1-20 Criteria for determination of style

5-2-2, 3).

In the survey 276 facades were observed in total. A total of 40% (111 buildings) in the survey displayed characteristics of a style, and the remaining 60% (165 buildings) had undergone some kind of modification (Fig.3-1-21).

The causes for loss of stylistic features were: loss of axisymmetric nature (35), replacement of windows and other such elements with modern materials (69), and the installation of one or more pairs of center-opening doors on a opening (67). There were also cases with multiple causes for loss of stylistic features, such as windows being replaced with modern ones in 49 of the 67 buildings where one or more pairs of center-opening doors were installed on a opening.

The following is a breakdown of the state of preservation of each style. In addition to only around 20% (54 buildings) of the buildings covered by the survey having floors from the third and above that survived natural disaster damage and a facade with features, their distribution within the community reveals that there are an extremely small number of locations where they exist in groups (Fig.3-1-22).

This survey provided a breakdown of the houses based on traditional construction methods that require preservation, reinforcement, repair and rehabilitation for townscape purposes.

While buildings with floors from the second and above that survived natural disaster damage and a facade with features can be said to be high priority for preservation, it was revealed that given that not many groups of buildings remain, there are many challenges

Fig. 3-1-21 Distribution map of the facade style of traditional houses in Khokana

Fig. 3-1-22 Distribution map of the houses which require rehabilitation

when it comes to townscape rehabilitation.

Given that around half of the buildings in the survey, while only having two floors, displayed features of a certain style, and thus it can be argued that the townscape can still be restored. The importance of creating a framework to make it easy to utilize the features of the remaining styles while working on reinforcement and repair became clear.

There are still many traditional buildings that do not have the features of the styles required for the rehabilitation of the townscape. It is expected that the details of the rehabilitation of the townscape will span a wide range of work, from minor work such as remaking windows and other facade elements with the materials used in traditional buildings, to major work to modify the position of openings. However, the preservation of remaining buildings and the reinforcement and repair of buildings that have stylistic features can be considered to be the priority.

When creating and implementing design guidelines, it will be desirable to create framework where options that set forth the directionality for repairs and reinforcements for each feature of the styles in the remaining facades are put together, and selections are made from these options for the rehabilitation of the townscape.

Furthermore, as the elements are checked in each building in this survey, in addition to the list of options, it should be possible to provide specific rebuilding guidance according to the state of each house.

3.1.2. State of Houses

For this survey, we classified houses in the scope as those that use traditional methods (timber-framed brick construction) and non-traditional construction methods, and then into buildings have extensions based on traditional construction methods and those that do not. With classifications that use the number floors, in our observations we focused on the rough outline of houses, layout, and the way they are lived in during.

1. Diversification in houses

1) 3.5 stories house

A feature of the way the Newar people traditionally use their houses is that each floor has a different role. With its earthen floor, the first floor is used to store things such as farming equipment or house livestock, the second and third floors are where the family spends time, and floor 3.5 - the attic - is where cooking and dining take place. Specific uses are thought to vary by community, but it is thought that the vertical structure where the first floor is used for storage, the second and third floor for daily life and sleeping, and the top floor for cooking and dining is the same.

2) 4 to 4.5 stories house

We conducted interviews about eight buildings on the main street that have undergone extensions. We found that all of them use the top floor as a kitchen. Some of them had made the roof flat, and there were also several where agricultural activities were performed. It also cannot be definitively said that the actual act of adding an extension to traditional buildings is a recent trend, and there were several persons who claimed that their house was extended before they were born. As such the general layout is more or less unchanged from (1), with the first floor being used for storage, the second and third floors used for daily life and sleeping, and the top floor being used for cooking and dining (and worship).

3) 4.5 stories house

In contrast to ②, these are buildings based on non-traditional construction methods. While they differ from timber-framed brick constructions, this number of floors is often seen in buildings with LB constructions that have the same wall constructions as brick masonry constructions. The height of the floor on the interior and stairs and other such aspect are as per the traditional construction methods, but they have a simple veranda. The appearance is almost entirely the same the RC construction described later. However, as they are inferior in terms of safety, they suffered major damage in the earthquake.

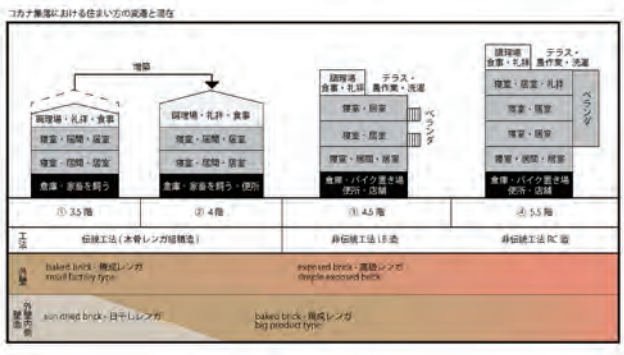


Fig. 3-1-23 Typology of houses in Khokana

4) More than 5.5 stories house

It was revealed that there were no significant differences in the use of the buildings in the vertical direction in houses built with modern non-traditional construction methods such as RC constructions and slabs. However, due to changes in technology and daily life there are significant changes in the structure, such as the appearance of verandas instead of eaves, and as the owners themselves now have more of a choice in terms of house design, individualized houses now stand out. This is also deeply linked to changes in industry such as an increase in the number of retailers.

It could perhaps be argued that we have arrived at a point of great change in the townscape with the appearance of RC construction. It was revealed that with the change in form, daily life and systems have reached a time of modernization, with the use of the ground floor changing from a storage place for livestock and agricultural equipment to one for motorbikes, and with water tanks moving to unused space on the ground floor or the roof to make use of unused space outside of the living area. These changes have also had an impact on the changes in townscape.

Considering general rule[2] applied in style chronology age estimates, it is speculated that houses in the Khokana community took the course of (1) traditional construction methods -> (2) traditional construction methods with extended areas -> (3) non-traditional construction methods.

Newar residences have forms including the most fundamental forms based on traditional construction methods, forms with extension where this is expanded upwards, and forms with completely new non-traditional construction methods. And the houses built with non-traditional construction methods can be classified based on whether they use a slab or RC pillar system. On the premise of a trend where the number of floors increases as the generations pass, given the form that structures take it can be said that (2) and (3) are derivatives of (1). The classifications of the survey performed in 2015 revealed that in the community there are buildings with extensions and those based on different construction methods, so the community contains the four types above.

While there are differences in the structure and form as in the classifications above, it is thought that there are almost no changes in the structure of use. It is thought that this indicates that while there have been changes in houses and daily life, the concept of clean and unclean based on caste remains strong as a norm.

In terms of modern demands, it has become clear that changes in industry and daily life have moved the activities that are thought to have been performed in courtyards and on frontage to the open spaces at the top of buildings. The changes in building for that have accompanied changes in daily life, such as agriculture on flat roofs, motorbike parking on the ground floor, and the appearance of balconies, have had a significant impact from the perspective of the townscape.

Construction materials have also been improved from the perspective of durability, precision, and other such things. Given the state of use of construction materials in non-traditionally constructed buildings, it is thought that there is a trend towards using the best, most expensive materials possible.

It can be thought that the creation of design guidelines for both traditionally and non-traditionally constructed houses taking into consideration the transition in lifestyle and the resulting changes in the form of houses as well as the aspirations of residents is preferable in order to achieve feasible townscape preservation.

2. Change in construction materials

This section describes the transition in construction materials through interviews with local specialists and craftsmen.

1) Bricks

① Sun dried bricks

These are bricks made with traditional methods based on sun drying, but given that they are extremely brittle and weak, they are no longer used in new constructions. They are seen in some walls in traditional buildings, and are not used in facades.

Fig. 3-1-24 Type of bricks used in Khokana

② Baked bricks / small factory type

It is thought that it is mainly this type of brick that is used in the naturally colored plain brick walls in the facades of historic buildings in Khokana. They were originally made in small volumes in small factories, so the degree of baking is not uniform, meaning some that are over-baked are brown and the shapes are not the same. They are no longer produced, so reuse is the main form of usage.

③ Baked bricks / big product type

This is thought to be the most common brick currently used in construction given its relatively low price and its strength. Facades are made with other bricks (such as the small factory type explained above and the exposed brick described below), but interiors and wall surfaces are made with these bricks. It is also used for restoration in some cases.

④ Exposed brick (brick with fine surface)

This is a more sophisticated brick that baked bricks, and is mainly used only in the facade. There are two types, one with a grazed surface and one without. When Dacchi Appa bricks are used, there are many cases where the bricks that are used incorporate ideas to make masonry joints invisible by filling the gaps created when bricks whose upper surface have been ground to a sloped angle are lined up with mortar.

・Simple exposed brick (Chinese brick)

・With oily surface (Dachhi Appa)

2) Windows

We interviewed Hera Lal Dangol, a window craftsman who currently lives in Khokana on November 11, 2016. He carried on his father's work and has 50 years experience as a window craftsman.

① Acquisition of materials

The wood used in windows is purchased and cut in Kathmandu, and then he brings the wood to Khokana in a small truck after which he makes the window components and does the carving himself. The general production process is as below.

Purchase wood (in Kathmandu) -> Cut wood (in Kathmandu) -> Take to factory and create window components (in Khokana) -> Carve wood (in Khokana)

② Window standards and orders

There are no statutory standards, but the width of wood used in windows is a uniform 35mm. The size and design of each window is decided using the details of the orders from home owners on the basis of the size and plan of their house. The design also copies the designs of the surrounding windows. There are no agents in this process. He used to make traditional type windows in the past, but now he has switched to modern type windows. He said that there is no longer a demand for old types.

③ Manufacturing technology

The craftsman also performs the carving. While in the past this was done by hand, for the last 25 years he has used a cutter and increased efficiency.

④ Sales channels

As well as the Khokana, he also distributes windows to other cities and settlements. Within Khokana, he shares orders for work with (five or six) other craftsmen.

Notes:

1. The following publications were referenced in the writing of this passage.
   ・Anton Schroll & Co-publishers "Kathmandu Valley - The Preservation of Physical Environment and Cultural Heritage. A Protective Inventory", 1975, Vienna.
   ・Wolfgang Korn, "The Traditional Architecture of the Kathmandu Valley", 1976, Kathmandu, University Press of Tribhuvan.
   ・Katherine D.Blair, "4 VILLAGES: ARCHITECTURE IN NEPAL", 1983, U.S, University pf Chicago Press. ・Niels Gutschow, Bernhard Kolver, Ishwaranand Shresthacarya "Newar Towns and Buildings", 1987, Germany, VHG Wissenschaftsverlag

2. The following is an overview of analysis based on style chronology, which if used in the estimation of a building's age.
   (1) If there are several modifications from A to B in a house, A is older than B.
   (2) If B is generally carried out these days, and if A is not, then A is older than B.
   (3) If A appears on older houses of those whose name is known through historic documentation, A is older than B.
   [How to View and Research Houses], edited by the Cultural Properties Protection Committee, 1969, page 84

3.1.3. General Information of Microtremor Measurements

(1) Outline of survey

Microtremor measurements were conducted on the traditional houses in Khokana on November 29 and 30 2015. To confirm the coupled vibration effect of interconnected houses, the measurements were performed at the same height for each house, monitoring two horizontal components. The measurements were performed four times. There was no external damage by the earthquake, but several inside partition walls were collapsed.

The 'all measurement points' are shown in Fig.3-1-25. The measurements were performed four times on all the houses to monitor vibration of in-plane direction and out-of-plane direction. The multiple measurements were performed at the one measurement point on free ground and at several points inside the houses. The ground point was in front of the houses , and the points inside the houses were at the top of the windowsill as it was difficult to place the velocity-meter on top of the wall. The measurements were conducted using a portable vibration monitoring system named SPC-51 and servo velocity-meters named VSE-15D, produced by Tokyo-Sokushin.

Fig. 3-1-25 All measurement Point

Fig. 3-1-26 Location of velocity-meters

(2) Measurement results

The result of the first measurement taken four times is shown below as an example. Five velocity-meters (Ch1 - Ch5) were placed at the points shown in Fig.3-1-26 to monitor the vibration of the in-plane direction. The Fourier amplitude ratio was obtained by dividing the Fourier spectrum of building vibration monitored inside the houses by the Fourier spectrum of ground vibration (Fig. 3-1-27). The frequencies which have peak in Fourier amplitude ratio are dominant frequencies. Ch1 was placed on the ground at the side of the houses, and Ch2 was placed on the windowsill on the 3rd floor. To compare Fourier amplitude ratios between the four measurements, Ch6 in case 1-2 and Ch3 in case 3-4 were fixed at the same position for the calibration. The vibration mode of each dominant frequency is shown in Fig. 3-1-28. The figures show that interconnected houses vibrate together in the in-plane direction at each dominated frequency, due to the coupled vibration effect.

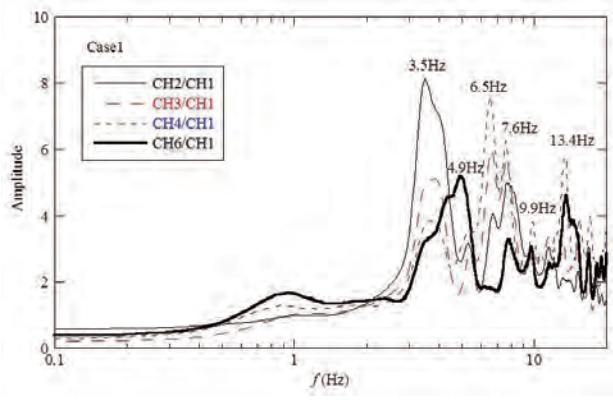
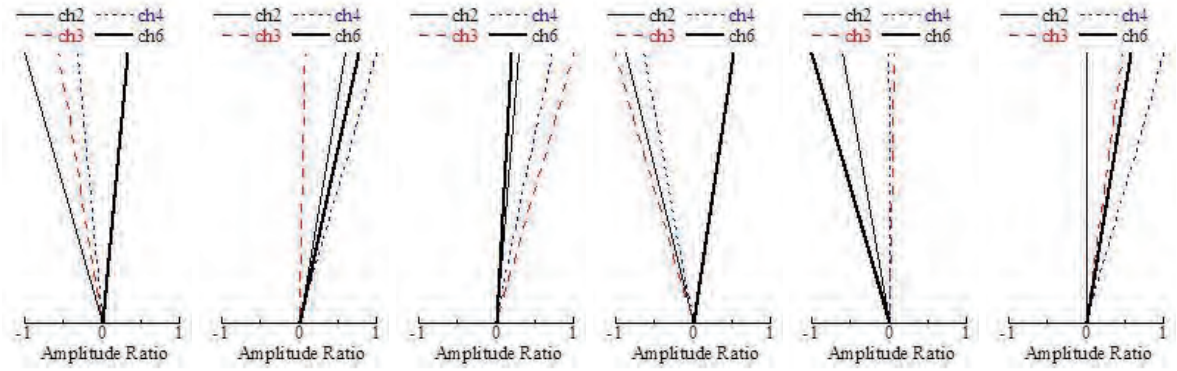
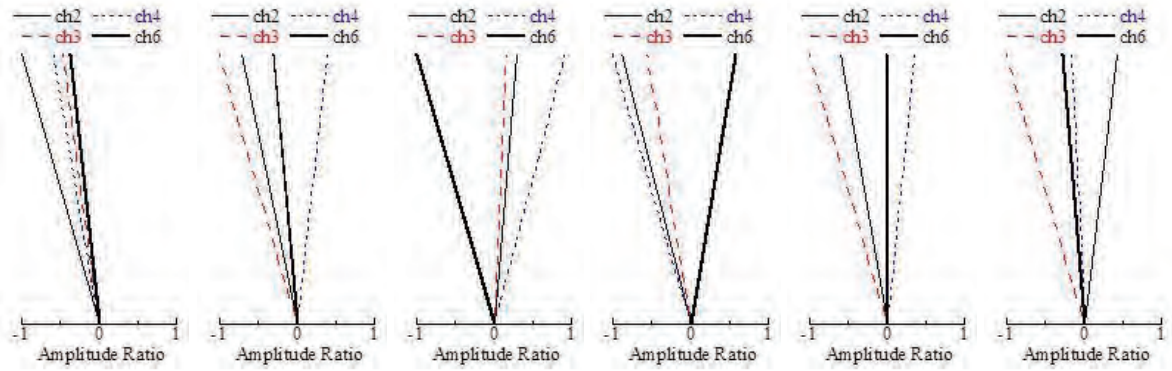


Fig. 3-1-27 Fourier amplitude ratios case 1 east-west direction



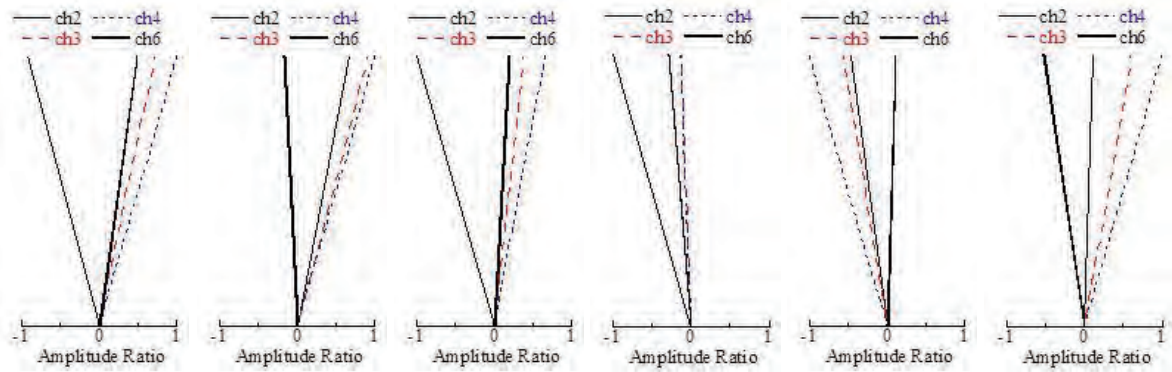
(a) 3.5Hz (b) 4.9Hz (c) 6.5Hz (d) 7.6Hz (e) 9.9Hz (f) 13.4Hz

Vibration mode（CASE1）



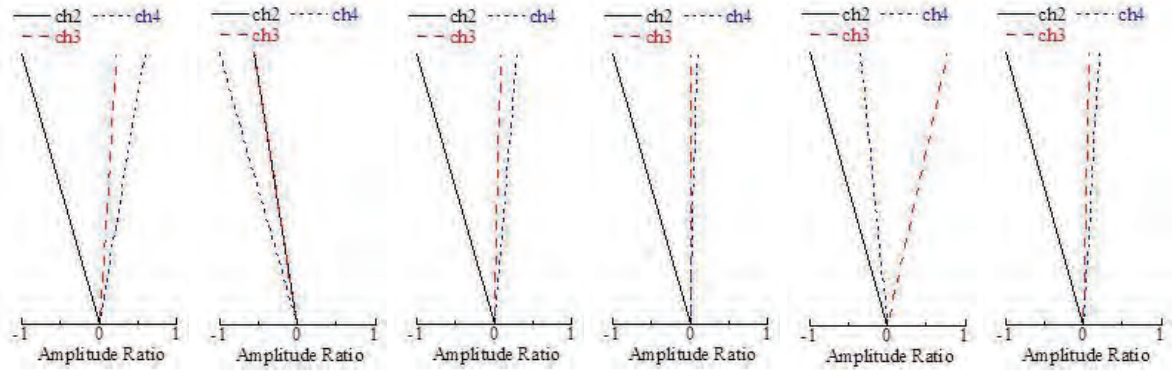
(a) 3.9Hz (b) 5.9Hz (c) 7.7Hz (d) 8.8Hz (e) 10.9Hz (f) 11.6Hz

Vibration mode（CASE 2）



(a) 4.0Hz (b) 5.1Hz (c) 6.7Hz (d) 8.2Hz (e) 11.2Hz (f) 13.5Hz

Vibration mode（CASE 3）



(a) 4.1Hz (b) 4.8Hz (c) 6.6Hz (d) 7.8Hz (e) 8.2Hz (f) 11.6Hz

Vibration mode（CASE 4）

Fig. 3-1-28 Vibration mode

3.2. Non-traditionally Constructed Houses

3.2.1. Classicication of Non-traditionally Constructed Houses

(1) Outline of the study

While advocating for the reconstruction of traditionally constructed houses, recent technical developments and changes in the modern life style are leading to an increase in houses with reinforced concrete. Demand is increasing with regard to safety especially in times of disaster and those looking for reconstruction using non-traditional construction methods are not few. To preserve a townscapes exemplary of Khokana, an effective option may be to combine and create guidelines for buildings using not just traditional construction methods but also non-traditional construction methods.

Our aim is to get a handle on details of the actual conditions of non-traditionally constructed houses that have heretofore not had historical material consolidated towards drawing up townscape guidelines for non-traditionally constructed houses.

LB Type RCC Type

Fig. 3-2-1 Types of non-traditionally constructed houses

ID	structure	building age
B016	LB	old(不明)
C017	LB	1989
C004	LB	around 1994
B011	LB	1996
A004	LB	2003
A013	LB	2003
B012①	LB	2003
A012	RCC	2005
B012②	RCC	2007
D011	RCC	2007
C019	RCC	2008
D016	RCC	2008
C003	RCC	2009
A010	RCC	2011
B017①	RCC	2012
D002	RCC	2012
B004	RCC	2013
B002	RCC	under construction
C007	RCC	under construction
C005	LB	(不明)
C013	RCC	(不明)
D010		(不明)
D014	LB	(不明)

(2) Survey of construction methods

1. Types of non-traditionally constructed house construction methods

The results from the field survey and interviews done on-site indicated that there were two types of buildings. Houses that could be considered the next stage of development for traditionally constructed houses made with a load-bearing wall construction method and those made with even more advanced techniques using reinforced cement concrete (pillar system). Load-bearing types can be placed at the high-level transitional stage between traditionally constructed houses and those made with reinforced cement concrete, when lifestyles and techniques were becoming more modern. Compared to load bearing, the strength of reinforced cement concrete is higher and there is a difference when damage has occurred. Geographically, Thalachi twa has more load-bearing buildings than Nayejho twa.

Fig. 3-2-2 Target area of the survey

Fig. 3-2-3 Relation between built year and house stories

2. Characteristics of construction methods in non-traditionally constructed houses

It became evident from the survey subject scope that load-bearing construction was introduced in around 1980 and that 2 decades later, 2004 marked the turning point where load bearing switched to reinforced cement concrete construction. Additionally,

the switch in construction methods allowed for the construction of taller buildings, increasing the amount of floor space and habitable rooms. It can be thought that lifestyle changes were tied to the increase in efficient usage of outdoor spaces like flat roofs and balconies, expanding possibilities for activities like doing laundry or raising plants.

3. Element of non-traditionally constructed houses

1) Ceiling height / Number of floors

It became evident from interviews with engineers and building owners that ceilings were made with a standard height of 8 to 9 feet. There were examples where the only the ground floor had a slightly higher ceiling of 9 feet, however interviews revealed that this was not related to use.

It is clear that the strengthening in construction when moving from load bearing to reinforced cement concrete construction led to taller buildings and an increase in floor space, with the number of floors rising to 4 and up after the appearance of reinforced cement concrete in 2004. Additionally, there were many cases where the top floor would have half of its space utilized, allowing for an ample terrace.

2) Depth

There are many houses made with 3 rows of columns, making a grid of 4. Spans along the frontage are made at even intervals (general standard is 1 span is a unit of 6 meters). Along the depth, however, there were many cases where the closer span was long (7 of 12 houses) , the span in the back was short when viewed from the front road (3 of 12) and all spans have same length (2 of 12). Additionally, there were many cases where this shorter span had a staircase built along it.

3) Staircases

The location of staircases was consolidated in 3 stages. The trend to place staircases in the area between the building and the building behind it was strong.

We saw trends classifying staircase morphology into 4 types and directions into 6. Load-bearing construction has many of the ladder-type that run in a straight line, without a landing. Reinforced cement concrete construction had many cases where landings were formed and the extra space was used to store shoes, items or as a family altar. In short, it's clear that in the move from load-bearing construction to reinforced cement concrete construction, staircases changed from the ladder-type to the landing-type and space utilization expanded.

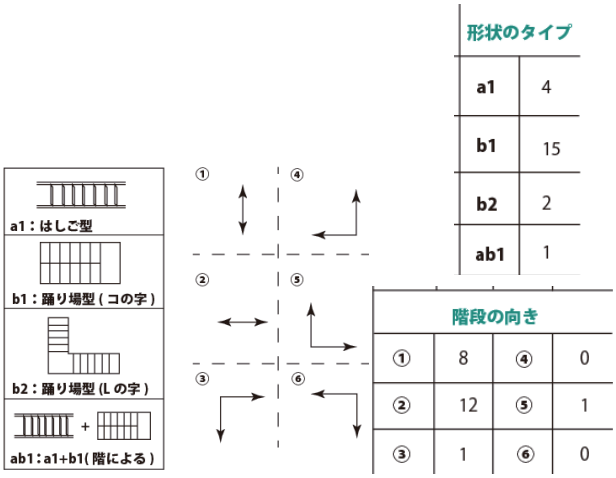
Generally, staircases are made in the space between a building and the building behind it, reinforced cement concrete construction sees landing-types, load-bearing construction sees ladder-types, and they are often placed in a direction parallel to the frontage.

4) Foundation

These are split into staircase types, slope types and mixed types.

There were many who said that the slope type was necessary for the putting in and taking out of bicycles, a major form of transport. Additionally, there were cases where a wider flat portion of the foundation was used for laundry, as a place to gather or as a play space. Additionally, the foundation plays an important role in living environments, acting as drainage during rainy seasons.

Problems lie in cases where foundations with steps are made exceeding the property line to modify the gap between the ground level to floor level of the ground floor. Additionally, there are cases where the townscape is disturbed on hills where the height of foundations is not uniform.



形状のタイプ	
a1	4
b1	15
b2	2
ab1	1

階段の向き			
①	8	④	0
②	12	⑤	1
③	1	⑥	0

Fig. 3-2-4 Types of form and direction of staircases

Fig. 3-2-5 Types of faundations, staircase type (Left) and slope type (Right)

(3) Survey of Facade design

1. Classification of facade design

The facades in the Khokana village's non-traditional houses were classified into the following 4 types.

a. Dazzling Type

We saw a trend among the affluent with a high aesthetic sense to choose this facade. There were many new constructed buildings that had had their facades remade in this type. There are points that feel a little off from Khokana's traditional facades, which might show the need to amend the standard of beauty in Khokana.

b. Personalized Type

A type where the owner expresses their individuality by painting the facade with a unique color. It could be thought that given the high frequency of comparatively flashy and repeated colors, issuing a warning based on having a uniform townscape might be in order. We also encountered a number of houses where half of the top floor's façade, which was difficult to see from the main street, was the only portion painted(likely independently).

c. Simple Type

An austere construction stemming from things like finance, the reinforced concrete construction actually contributes to the uniformity of Khokana's townscape. The bricks in the facade are simple, there is very little decoration and it can be thought that of the reinforced cement concrete patterns, this design is the one that blends best with Khokana's unaffected traditional building scenery.

d. Faux-Traditional Type

There was 1 exception, a reinforced cement concrete building designed to look traditional. This was a house that 4 families had jointly reconstructed.

We assume there is a trend to favor the "a type" at present, however, we think that it's more suitable to think of guidelines for reinforced concrete with detailed facilities that have a basis in the "c type" to protect a townscape exemplary of Khokana. However, it could be said that the people of Khokana, with beautiful facades that take the scenery into consideration, have a high aesthetic sense.

2. The current state of spatial elements and related problems in facade creation

Next, with regard to the current state of each element in the creation of facades in reinforced cement concrete constructed houses, we've compiled an overall analysis of each element and the different properties of each of the aforementioned a, b, c and d types.

1) Brick / Pillar concealment

We saw facade types consisting of mortar, brick, painted brick and of those treated with plaster. Additionally, there were many houses among those with brick facades designed where consideration was given to the scenery through hiding the pillars and girders behind a single layer of brick, so they could not be seen from the front. This sort of intentional pillar concealment with consideration given to scenery is an important point in scenery consideration that needs to be promoted in coming guidance related to the townscape.

a. Dazzling Type

- Dacchi Appa bricks are used
- Pillars are concealed

b. Personalized Type

- Baked bricks + paint / Baked bricks + mortar / Plaster
- There are houses that concealed pillars and those that do not (Mainly, either bricks were used to hide the pillar or the pillar itself was painted another color(white was


Mortar


Brick


Brick+Paint


Plaster


Pillar concealment

Fig. 3-2-6 Type of wall finishing

a. Dazzling Type

b. Personalized Type

c. Simple Type

d. Faux-Traditional Type

Fig. 3-2-7 Classification of facade design

frequent))

c. Simple Type

・There are houses that concealed pillars and those that do not (most concealed)

d. Faux-Traditional Type

・Pillars were not concealed.

・Baked bricks were painted over to prevent decay.

2) Masonry joint

We compiled masonry joints in facades into the following three classifications. Among those, as the ① type had low strength and was utilized in traditionally constructed houses, non-traditionally constructed houses used the ② and ③ types.

① Masonry mud mortar joints

Mainly used in traditional houses, it has low strength and is no longer widely used. It has yellowish tinges.

② Masonry mortar joints

Currently commonly used. Compared to ① , it has blue-black tinges.

③ Hidden masonry joints

Bricks in the facade are laid at a diagonal. There were many houses that used mainly oily Dachi Apa type of bricks.

a. Dazzling Type

Can be said to be characterized by hidden masonry joints through ③ 's unique bricks.

b. Personalized Type

・Brick only or painted brick mainly used ② mortar masonry joints.

Mud mortar

Mortar

Dachi Apa

Cutted brick

Fig. 3-2-8 Types of brick joints

c. Simple Type

・Mainly ② masonry joints.

d. Faux-Traditional Type

・② masonry joints were coated with paint.

3) Windows / Openings

Generally, there were no set standards or restrictions with regard to windows in non-traditionally constructed houses, with the owner freely selecting the design and style and ordering with a craftsman. Wood frames with a glass window fitted inside of the 口 type (modern type) were commonly used, and we also discovered windows that had portions that were not movable in the interest keeping costs low. The wooden portion of modern type windows had was not engraved much, and was painted. There was no standard for consideration given to living habitat with things like lighting or ventilation.

On the other hand, there were recycled triple windows and windows with engravings with shape that conformed to the traditionally constructed house (neo classical style) standard of having 5:3 vertical/horizontal ratio. In this case, too, glass was fundamentally used. Additionally, we also found houses that used aluminum sash windows to save money, and it could be said that some kind of regulation is in order to maintain the townscape.

a. Dazzling Type

・There were many windows where the wood frame was painted with the owner's favorite color. Mainly simple wood frames without engravings. Engraved, beautiful windows with dignified construction were also used here and there. Colors were mainly dark browns and blacks.

b. Personalized Type / c. Simple Type

・There were many windows where the wood frame was painted with the owner's favorite color. Mainly simple wood frames without engravings. Engraved, beautiful windows with dignified construction were also used here and there. There are many using white that can be thought to be inheriting a neo classical lineage.

d. Faux-Traditional Type

・Has engraved triple windows and 5:3 ratio II type windows. Double-layer construction with window glass fitted into an engraved wooden frame that has been painted black.

4) Cornice

Another important element in facade design is the cornice (horizontal lines). We classify the cornice in Khokana's reinforced cement concrete into the following 2 types..

① Decorative type: Engraved brick cornice

② Simple type: Simple cornice

③ Other cornice (if it exists)

a. Dazzling Type

A gorgeous cornice made using high-quality bricks that have decorative engravings. It can be thought that this is the only type used in the application of cornice that extends out from the side of a window's mid-point.

b. Personalized Type

A cornice container with simple bricks in between, it has no decoration as it is brought together with plaster or cement, or because a balcony is present.

c. Simple Type

A cornice container with simple bricks in between, it has no decoration as it is brought together with plaster or cement, or because a balcony is present.

d. Faux-Traditional Type

Uses special bricks, but is simple and not too flashy so as to match with the neighboring traditional style.

5) Balcony / Terrace

One large change in style from that came along with the evolution of techniques and morphology that the move from traditionally constructed houses to load-bearing/reinforced cement concrete construction brought was the increase in open-air space that came with balconies and terraces. As we stated that it is understood that this change in style brought a move for the space daily activities like laundry and sun-drying of grains were done in, taking it from the front of the house and courtyard along a horizontal/vertical line, where the height of the space could begin to be utilized.

In general, as the space in balconies is limited, their utility is not that high, leading to mainly being uses consisting of storage, drying laundry or looking out at the scenery. On the other hand, as terraces have a comparatively wide area, they have many uses as a place that can be used for sun-drying, for laundry, to raise plants or as a place for children to play. Built using half of the capacity of the top floor, there are many houses with 2 level terraces with outdoor spiral staircases affixed on the side to move between them. Installation of balconies will not be possible due to a coming by-law.

Modern window of a. Dazzling Type house

Modern window of b. Personalized type house

Alminium sash window of c. Simple Type house

Triple window with 5:3 ratio of d. Faux-Traditional Type

Fig. 3-2-9 Types of windows

Cournice of a Type

Cournice of b Type

Cournice of c Type

Cournice of d Type

Fig. 3-2-10 Types of cournices

Fig. 3-2-11 Example of balcony (c Type)

Fig. 3-2-12 Utilization of terrace space

Fig. 3-2-13 Two levell Terraces

Fig. 3-2-14 Wooden braces (a Type)

Fig. 3-2-15 Eaves with Slab (a Type)

Fig. 3-2-16 Eaves similat to traditional one

a. Dazzling Type

- Balcony : Not installed
- Terrace installed (1 level)

b. Personalized Type

- Balcony : Installed (upper than second floors)
- Terrace installed (2 level)

c. Simple Type

- Balcony : Installed (upper than second floors)
- Terrace installed (2 level)

d. Faux-Traditional Type

- Balcony : Not installed
- Terrace installed (2 level)

6) Eaves

Different from traditionally constructed houses, non-traditionally constructed houses have no functional need for eaves. Additionally, the arrival of balconies meant that houses will fundamentally not have eaves. However, there are cases of eaves being recreated in a quasi-manner, and we have compiled them according to the 4 facade types below.

a. Dazzling Type - Gorgeous

- Many had their face, which is flat, made by extending the slab and were affixed as decoration. In that case, undersurface of the eaves is painted and fundamentally, as they don't have tiles or braces and aren't using wood, they are finished in a manner that differs greatly from the traditional style. Additionally, there were cases where there are portions with engraved wooden braces affixed. However, it's hard to say that harmony is being maintained in a consistent townscape with regard to the eaves in traditionally constructed houses, as there are proportion differences in things like the positional relationships between windows and braces.

b. Personalized Type

- No eaves. In place of eaves, balconies or terraces jut out.

c. Simple Type

- No eaves. In place of eaves, balconies or terraces jut out.

d. Faux-Traditional Type

- Has eaves painted black with proportions similar to that of traditional style. Finished with braces coming out of the side of windows and tile over the top. We've decided to promote this morphology in the coming guidelines.

(4) Color space in Khokana

Color is one of the elements brought up as protecting the historic townscape exemplary of Khokana. Along with increases in the selection of color options that came as a result of developments in things like differences in material and painting, the shape and color of buildings are diversifying, the sense of unity is dropping, and great change is continuing. Going from that sort of problem-focused consciousness, we performed a basic survey of the characteristics that make up Khokana's urban space and classified them, looking towards the creation of a standard that guides building coloration. We calculated the on-site, daily, visual Munsell value of Ultra Weatherability Fluoropolymer Paint Bonnflon based on the Japan Paint Manufacturers Association published Standard Paint Colors 2011 Pocket F-edition[1].

1. Color space in Khokana

The analysis for color space was divided into 3 large categories as followings. The "spatial color" that makes up the color scheme that is Khokana's color space as a town, the "architectural color" that is used unnaturally on buildings as customs or culture, and the materials and components that make up those colors, the "color elements".

① Spatial color

Thinking about the color of buildings as a standard, there is a need to give consideration to the matching of coloration in the environment that each of those buildings is placed in. We have compiled points that are important to consider regarding the town color of Khokana village.

- Rice field

The color of the expanse of terraced rice fields surrounding Khokana village changes with the seasons and brings out the color of the village[2].

- Pond

A reservoir located in the middle of the village. However, as the color is muddy, the bottom cannot be seen. Some kind of measure is needed to make a resource for color in the scenery.

- Main street

The coloration of the main street that retains a historical townscape will become the most basic standard in the coming color guidelines[3].

② Architectural color

Looking towards color guidelines, we surveyed the traditional

color schemes and color distribution that make up the base of Khokana's traditional scenery coloration.

③ Color elements

The traditional color schemes described above will be subdivided, and regulated by individual material and element color. We have compiled traditional materials and components such as bricks, masonry joints and pavement, to regulate color from materials alongside the color guidelines.

2. Scope of color in Khokana

We plotted how colors are scattered using mainly Khokana houses as the subject[4]. The range of RGB value of color elements measured in Khokana are shown in Fig.3-2-22. Colors of mid-to-low brightness were common in Khokana. This distribution will become the basis for the color guideline and YR/R colors will become predominant, but for minute differences like those in the style of the royal palace, there is a need to regulate bricks starting from their material. Additionally, further minute survey is required, as wooden portions will weather and change color as time passes.

3. Field study of house colors[5]

① Predominant color

The survey on the state of outer walls, which have a large effect on the coloration of the townscape was conducted. We understood that colors aside from the YR/R base that makes up Khokana's townscape are used. Additionally, there is a need to be careful even with the YR/R colors, as differences in intensity and brightness can bring changes to the atmosphere.

② Color of ground floor openings[6]

The current state is one where some sort of guidance is required as, aside from wall coloration, the openings that also has a large effect on the look of the townscape has unique coloration. The openings of the ground floor has a larger area when compared to the wall, so it can be thought that it has a large effect on the townscape scenery.

③ Accent color

Of the 42 houses that were within the survey subject scope,

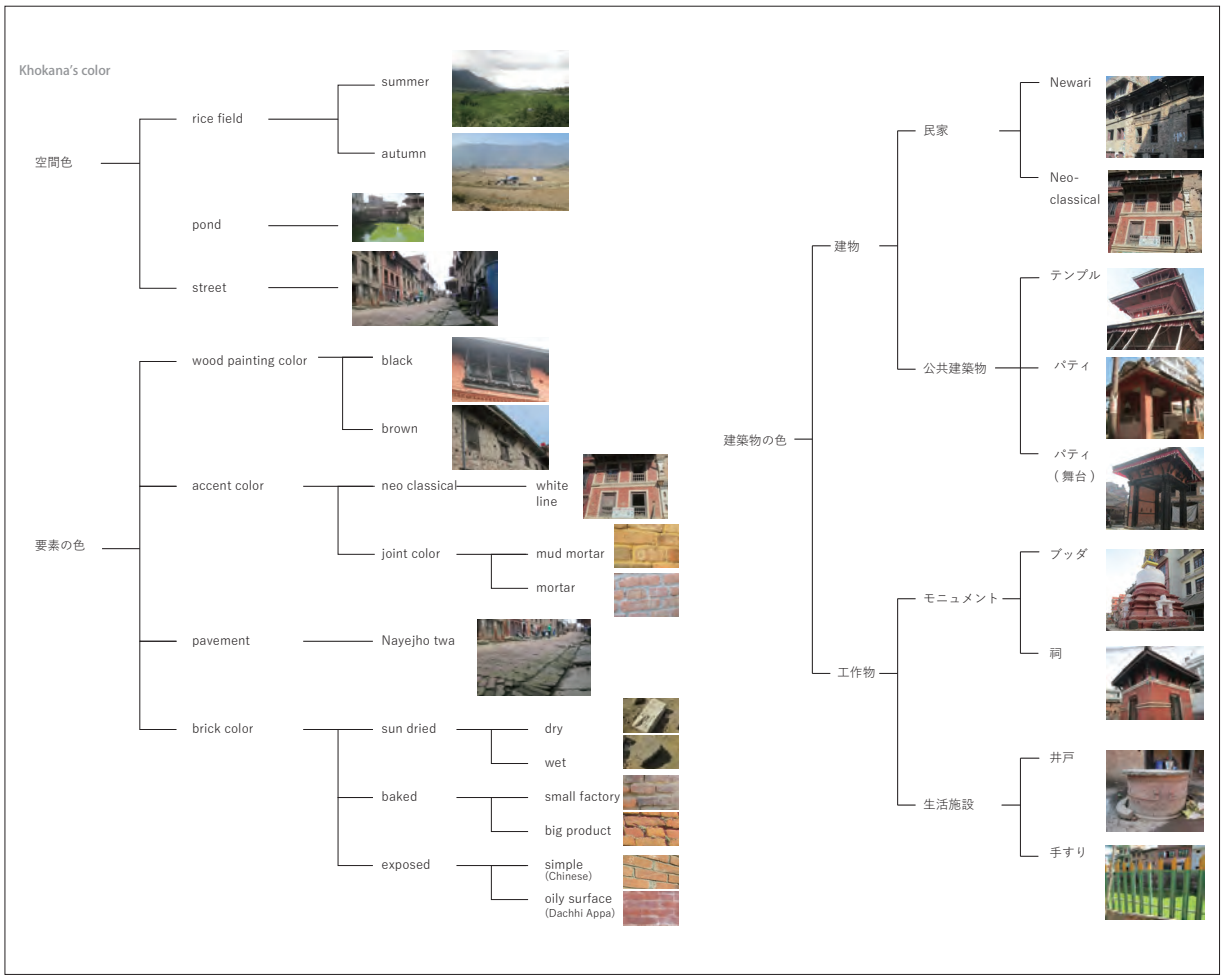
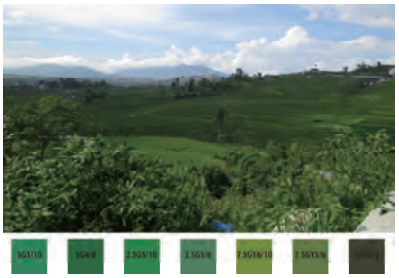


Fig. 3-2-17 Typology of color space in Khokana

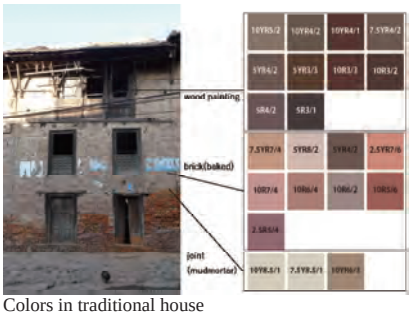


Rice field in rainy season (September)

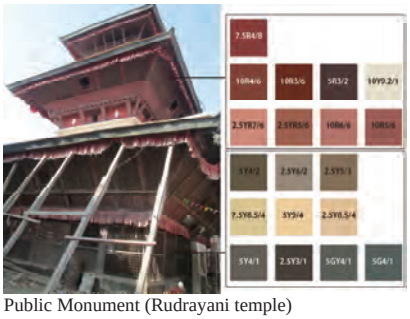
Rice field in dry season (November)

Pond

Nayejho twa (September)

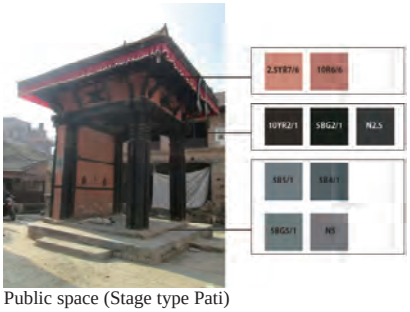


Colors in traditional house



Public Monument (Rudrayani temple)

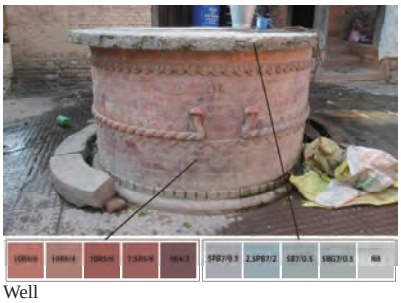
Public space (Pati)



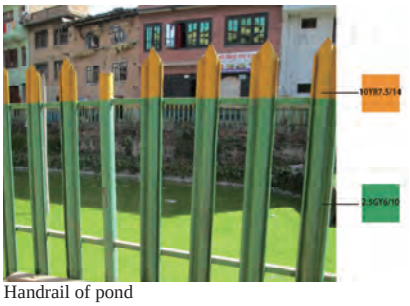
Public space (Stage type Pati)

Monument (Buddha)

Monument (small shrine)



Well



Handrail of pond

Fig. 3-2-18 Mansell value of color space in Khokana

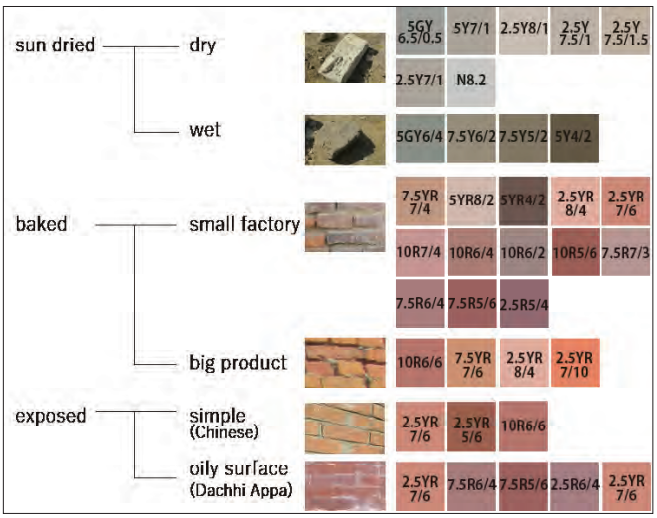


Fig. 3-2-19 Mansell value of bricks used for houses in Khokana

Fig. 3-2-20 Mansell value of joint material

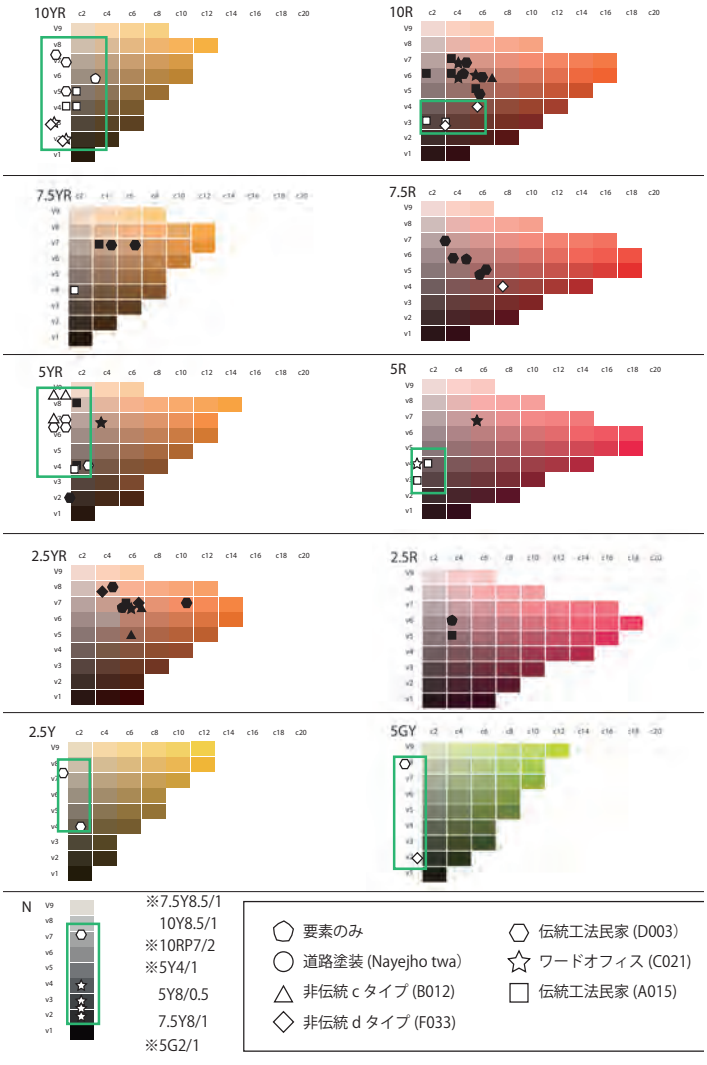
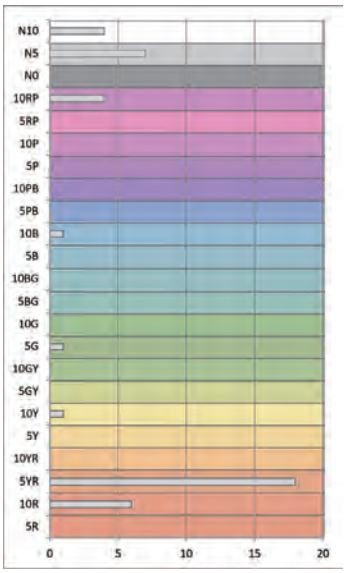


Fig. 3-2-22 Range of RGB value of color elements measured in Khokana

Fig. 3-2-21 Mansell value of pavement of main street



外壁（基調色）	
N10	4
N5	7
N0	0
10RP	4
5RP	0
10P	0
5P	0
10PB	0
5PB	0
10B	1
5BG	0
10BG	0
5BG	0
10G	0
5G	1
10GY	0
5GY	0
10Y	1
5Y	0
10YR	0
5YR	18
10R	6
5R	0
調査戸数	42

Fig. 3-2-23 Distribution of Mansell value of color elements of house facade

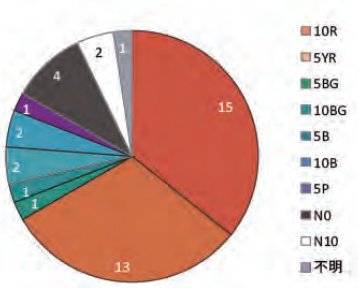


Fig. 3-2-24 Ratio of color in openings of ground floor

Fig. 3-2-25 Examples of accent color

we saw a trend in 23 (55%) to sectionally use white paint on components. The causal relationship is unknown, but white is a neo classical style accent color.

Additionally, there was a proportionally high number of houses that had similarly used blue as an accent color in the painting of components. Of the 42 houses, 18 (approx. 43%) were seen as having blue.

As mentioned before, there is a trend in hiding pillars and slag, however, 5 of the 42 houses used designs where pillars or beams were painted a different color from the wall's predominant color, making them stand out.

(5) Other problems

We saw houses where water pipes were installed in front of the facade, damaging the scenery. It can be thought that for houses that had flat, not pitched, roofs, this is how wastewater is disposed of. Measures are necessary looking towards the improvement of the townscape scenery.

Since coming technological innovations and changes in lifestyle will make the change of townscape accelerate, it can be thought that it's necessary to think of measures not just to restrict placement of facility open-air installations but also of the utilization of public spaces to maintain the convenience of daily life.

Notes:

1. In expressions of color examples, we're using an RGB value we calculated from Munsell Value's taken measured from a portion of on-site photographs using the Paint Color Search System released by the Japan Paint Manufacturer's Association. Additionally, in order to visually ascertain representative colors in spaces where there were many different colors scattered around, the expression is limited and not comprehensive.
2. As we did the color survey during the dry season, November, we sampled the colors of the rainy season from photographs. A detailed survey looking towards minute guidelines is desirable.
3. Sampling of representative colors from pictures. Individual elements of each color will be concretely compiled based on an on-site survey in the next chapter.
4. This survey has limited values, with plots taken from only 6 houses (A015, B012. C006, D003, D011, F03) and 1 public facility (C021).
5. In the color field study, we surveyed 43 houses, as the traditionally constructed houses of the target scope were also made targets of the survey.
6. Color of the door shutter takes precedence when there are more than 2 colors

4. Damage Condition After the Earthquake

4. Damage condition After the Earthquake

4.1. Exhaustive Survey of Damage Condition

(1) Outline of the survey

On 25 April 2015, a 7.8 magnitude earthquake with its seismic centre in the Gorkha region in Central Nepal struck, taking the lives of nine people in Khokana Village. The village itself, which is listed on the World Heritage Site Tentative List, was also seriously damaged. This report details the findings of a exhaustive survey conducted of buildings facing the street in the Southern Settlement Area, which is the main part of the village, from the perspective of preserving the townscape of the village neighbourhood; its aim is to gain useful insight for the recovery plan for this area.

Referring to past research[1] and interviews conducted with specialists[2], buildings were classified as traditional construction (mix structure of brickwork and wooden frame) or non-traditional construction (Reinforced Concrete (RC) Build: C Type), with traditional construction being further divided into those having no extension work (A Type) and those with extension work (B Type)[3]. Regarding damage level, we established the three stages of heavy, moderate, and slight[4]. This survey focused on using eyesight to appraise the disaster damage to facades from the perspective of townscape preservation.

We resided at the site from 22 November to 6 December 6 2015, and conducted the survey with a total of seven members, comprising: two faculty members of the University of Tokyo, Urban Design Lab, two students enrolled in the masters' degree programme, Professor Bijaya Shrestha of Khwopa Engineering College (a graduate of Tokyo University), and two of his students. Based on two person's teams comprising one person from Tokyo University and one from Khwopa Engineering College, each building was assigned a number, had its façade photographed, and had its measurements taken focusing on:

- number of floors;
- number of added floors;
- the existence of partitioning;
- the purpose of the ground floor;
- wall thickness;
- frontage; and
- ceiling height,

while also judging the stage of damage level based on the building classification described above.

(2) Survey result and considerations

Through the exhaustive survey, records were taken for a total of 596 buildings in both the Northern and Southern Settlement Areas. We will perform an analysis on 577 buildings[5] in the Southern Settlement Area.

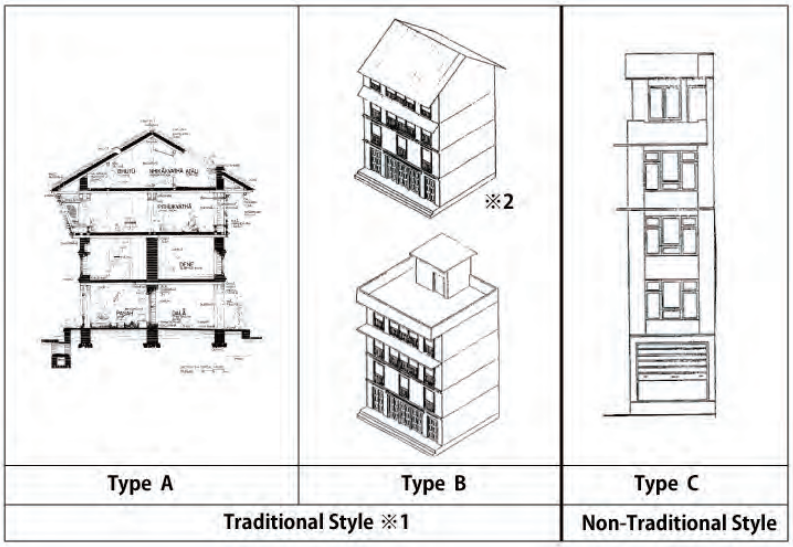


Fig. 4-1-1 Building typologies (Quoted note 3, modified by author)

*1 if it is difficult to judge by collapse, the building would be defined as Type AB

*2 Even if the building had been expanded, it will be regarded as Type A if it is in good condition.

Fig. 4-1-2 Three stages of damage level (from note 4)

1. Building ratio by construction method

Regarding the building ratio by construction method, approximately 60% of the total buildings are made from traditional construction methods (Fig. 4-1-3, 4).

2. Disaster damage condition

Because this survey strictly concentrates on disaster circumstances pertaining to the external appearance of buildings, it is taken as a premise that its results will not match those of a structural survey. However, based on our observations approximately 15% of the traditionally constructed buildings were totally destroyed, half were partially destroyed, and approximately 40% were slightly damaged or undamaged (Fig. 4-1-5,6). Regarding the disaster circumstances for the 232 non-traditionally constructed buildings, approximately 96% were slightly damaged or undamaged (Fig. 4-1-9), but we also learned through the interviews that there were cracks inside the buildings and curving in the floors. The detail of this damage is a subject to be addressed in the future.

3. Issues related to the damage to traditionally constructed buildings

Besides the issue of the reconstruction method to be used for the 52 totally destroyed buildings, it is also necessary to establish whether existing repair reinforcement construction is possible for the 163 traditionally constructed buildings (Fig. 4-1-7) that have been partially destroyed, and the necessity of a fixed and specific presentation of methods. The residents of these partially destroyed buildings have dismantled the upper floor part of their collapsed houses and have covered the ceiling with zinc-coated steel (Fig. 4-1-8); they continue living bi-local lives, using the toilet facilities and storage spaces of their houses during the day, and sleeping in temporary residences at night.

4. Issues and considerations for non-traditionally constructed buildings

Among non-traditionally constructed buildings, we observed many mainly five-storey buildings, made principally of reinforced concrete as their main structural part, with brick masonry on the exterior walls. The equally distributed non-traditionally constructed buildings (Fig. 4-1-9) pose a serious obstruction that damages the townscape. This research focused on the materials and finishing used on the surface of these buildings and their floor height for both sides of the neighbourhood constituting the façade of the Main street; we conducted the following analysis with the aim of apprehending the current situation.

1) Materials and finishing

On both sides of the neighbourhood along the Main street, we classified the materials and finishing that constitute the façade and conducted analysis after calculating the distribution area. In Façade A, despite 11 out of the 15 buildings (approximately 70%) were traditionally constructed buildings, the results for the distribution area of the wall material and finishing constituting the façade showed that it was in equal proportions constituted of brick and mortar/painted wall (Fig. 4-1-10,11,12). Half the surface area of the façade was replaced with modern materials. Moreover, on the traditionally constructed buildings, a trend was observed towards finishing the ground floor and the entire surface with mortar as a technique for repairing exterior walls; there was also an observed trend of finishing non-traditionally constructed buildings with vivid colours. Detailed analysis of roofs, bracing, tiles, and wood carved windows that serve as important elements of traditionally constructed buildings is an issue for future consideration.

2) Ground floor ceiling height

We learned from analysis of the ground floor ceiling height ascertained through the total survey that, whereas the average ceiling height for traditionally constructed buildings is approximately 1,900mm, the average ceiling height for non-traditionally constructed building is 2,500mm (Fig. 4-1-13). Changes in ceiling height naturally impact on the neighbourhood townscape. In this research, we next created and analysed a cross-sectional Figure of the Main street.

3) Townscape cross-section

On the main street, we created and analysed separate cross-sectional Figures for traditionally constructed buildings (Section A) and non-traditionally constructed buildings (Section B) (Fig. 4-1-14). The difference in the floor heights and number of floors for traditionally and non-traditionally constructed buildings is clearly changing the townscape of the neighbourhood. There are also many buildings that raise the floor height of the ground floor, and concrete stairs to eliminate the resulting gap have appeared, thus changing the landscape of the ground level. There is a tendency

Tab. 4-1-1 Survey Sheet

OUTLINE	**Style**	☐ A ☐ B ☐ C
	Damage	☐ Total ☐ Half (story:) ☐ Facade remains ☐ Little/None
	Story	☐ 1st ☐ 2nd ☐ 3rd ☐ 4th ☐ 5th ☐ 6th
	Added Story	☐ 4th ☐ 5th ☐ 6th ☐ None
	Vertical Division	☐ Divided (Number:) ☐ Not divided ☐ Unknown
	Corner	☐ In a corner ☐ Not in a corner
	Housing Type	☐ Type Ⅰ ☐ Type Ⅱ ☐ Type Ⅲ ☐ Type Ⅳ ☐ Type Ⅴ ☐ Unknown
	1st floor usage	☐ Housing ☐ Retail ☐ Storage ☐ Animals Shed ☐ Pati ☐ Walk through path
	1st floor size	CH: mm Storefront: mm Wall thickness: mm
	2nd floor size	CH: ☐ Lower than other stories ☐ Same ☐ Unknown
	Structure	☐ Bricks ☐ Timber frame + Bricks ☐ RC Addition: ☐ Bricks ☐ Timber frame + Bricks ☐ RC
	Brick Type	☐ Baked Bricks ☐ Sun-dried Bricks
	Masonry Joint	☐ Mud ☐ Mortar ☐ Unknown

Fig. 4-1-3 Distribution map of traditional method of construction buildings in the southern settlement area

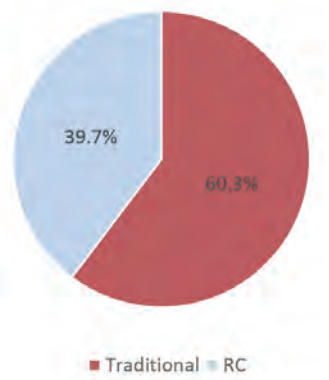


Fig. 4-1-4 The ratio of traditional construction buildings and RC buildings in the southern settlment area

Fig. 4-1-5 Disaster damage consition of traditionally constructed buildings in the southern settlement area

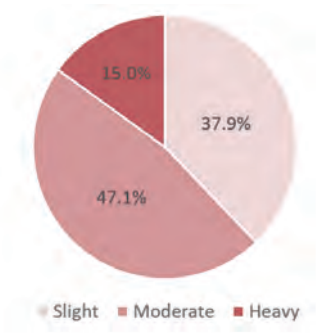


Fig. 4-1-6 Damage level of traditional houses

Fig. 4-1-7 Dirtribution map of half collapsed traditionaly constructed buildings in the southern settlement area

Fig. 4-1-8 Half collapsed traditionally constructed buildings

Fig. 4-1-9 Distribution map of non-traditionally constructed buildings in southern settlement area (Slight and moderate damage)

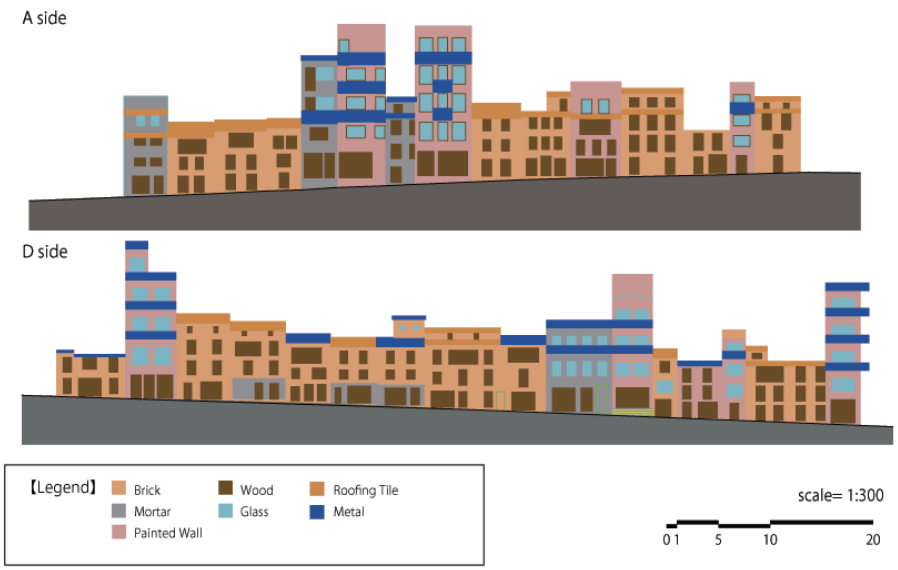


Fig. 4-1-10 Materials and finishing that constitute the façade of the main street

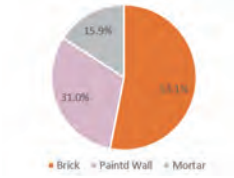


Fig. 4-1-11 Percentage of wall materials on A side

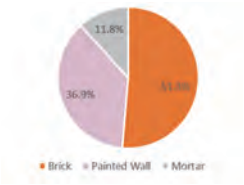


Fig. 4-1-12 Percentage of wall materials on B side

to use the ground floor as a garage for motorbikes and there were also observed cases of making a slope down to the street (Fig. 4-1-15). The degree to which the order of Newar living spaces detailed in past research[6] is carried on in non-traditionally constructed buildings is an issue we would like to address in the future.

4) Considerations

There were many non-traditionally constructed buildings to which earthquake damage was minor. Therefore, from the perspective of the disaster recovery, there was comparatively little discussion on non-traditionally constructed buildings; as detailed above, though, there are many issues concerning townscape preservation. In the future, we suppose there is a significant possibility that reconstructed buildings will follow non-traditional construction methods; however, it is necessary to clarify the issues and formulate design guidelines in a direction that will not damage to the traditional townscape.

Notes:

1. Rohit Jigyasu et al., 'Katomanzu keikoku no dentōteki shūraku bungamati no henyō to seijakusei no zōdai ni kan suru kenkyū' (Study of Change and Increase in Fragility in Bungamati, a Traditional Village in the Kathmandu Valley) Rekishi toshi bōsai ronbunshū (Studies in Disaster Mitigation for Urban Cultural Heritage, Vol. 3, pp. 195-202, June 2009
2. We received advice on Oct 23rd 2015 from Professor Masaya Masui of Kyoto University who participated in the September 2015 survey in Bhaktapur (Projected selected for grant funding for scientific research of Associate Professor Yamamoto Naohiko of Nara Women's University)
3. UNESCO: Heritage homeowner's preservation manual, 2006
4. EMS98 (G. Grunthai (Editor)): European Macroseismic Scale 1998, 1998
5. Includes three cottages. The breakdown of the 593 building excluding the cottages is 577 buildings in the Southern Settlement Area and 16 buildings in the Northern Settlement Area.
6. Ratna Keshari Prajapati et al., "Newaaru-zoku no sumai ni okeru hitobito no kōdō to kūkan ninshiki kara miidasareru kūkan gainen, nepaaru/katomandu bonchi no kokana to bungamati no baai," (Spatial Concepts Identified in the Actions)

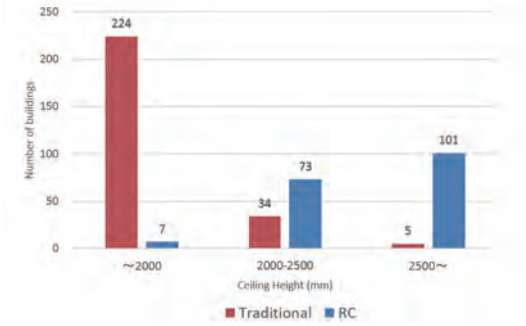


Fig. 4-1-13 Ground floor ceiling height of traditional and non-traditional buildings

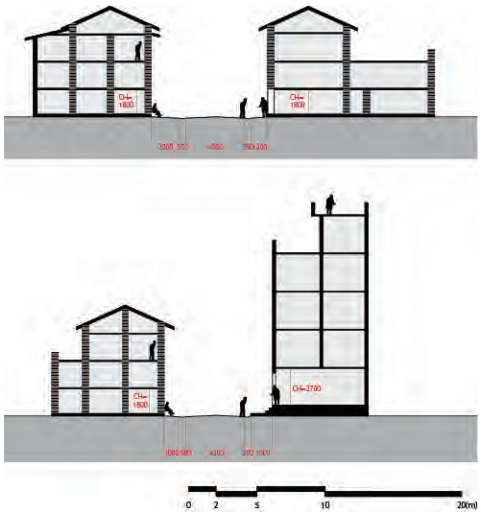


Fig. 4-1-14 Section diagram of the main street

Fig. 4-1-15 Slope to the main street

4.2. Analysis for Damaged Houses

4.2.1. Conjecture on the Factors Affecting the Damage Level of Buildings

(1) Outline of the Survey

From our investigations of the townscape, we postulate that traditional houses or their townscape became fragile structurally by extending and renovating their original states. We thus examine how the transformation of houses and their townscape may have influenced the damage caused by Gorkha earthquake, that is, the relation between the formal-spatial transformation and the disaster damage, based on the field survey of damage and collapses both inside and outside the houses. (For the details of the building numbers used in this investigation, see Chapter 2, Section 6.)

The issues of this investigation are not based on structural analysis; nor would they become direct contents of Design Guidelines either. However, we indicate the causes of damage or collapses of houses that are surmised by our survey.The visual survey of damaged houses and interviews with residents inside the investigated site were conducted.

This section shows the following six factors that were observed inside the investigated site. It also includes some damaged houses outside the investigated site to provide clear cases of each factor.

1. Insufficient connection between original part and extended part;
2. Loss of horizontal rigidity caused by installation of interior staircases after segmentation;
3. Fragile structure of the annexes built at the rear;
4. Damage to low-rise houses caused by water storage tanks falling from high-rise houses;
5. Use of fragile construction materials; and
6. Inappropriate construction methods.

(2) Reflections

Reflection 1: Causes of the damage and collapse

1. Insufficient connection between original part and extended part

Concerning the houses in the investigated site (along Nyala Dan Street), there are many cases of three-storey houses with transformed attics and one floor added on top of the third floor (S12 and N14). Those houses, therefore, weigh more than they did prior to the extension, and their structure is consequently weakened by the extension with insufficient connection between original part and extended part. This would be a significant factor contributing to the breaking of the connected part in the event of an earthquake. We cannot say that the extension directly causes the damage or collapse of houses if they are small-scale works, such as kitchen extensions involving installation of side walls. In the case of Kirtipur, where we see lots of cracks under the extended area of houses (Fig. 4-2-3), it is considered that the increase in weight, despite the extension of only one floor, influenced the scale of the damage. We also found cracks running over the inside wall of the floor directly below the extended floor (S13) because of the difference in strength between the beams of reinforced concrete and the existing brick walls at the interface.

After the distribution of property from parents to children (i.e. conversion to more than one household), houses are divided by household and each then extends their own space. There are some traditional houses with parts which were intensively damaged because those houses were partially extended, thus causing their loads to become unbalanced (Fig. 4-2-7, and 4-2-9).

We sometimes found remarkable examples of houses which have increased in weight in Khokana (though not inside the investigated site). In essence, they left fragile brick walls on the lower floor and extended on the upper floors using reinforced concrete. In such cases, the upper floors cannot easily be demolished due to the danger of collapse, and this dangerous situation for neighbours still remains. The removal of wreckage after the collapse of houses extended by reinforced concrete, which are different from those extended by brick, has become a serious problem.

Extension is the vertical connection onto a building, but the connection in the horizontal direction is also a factor in the damage and collapse. As seen in Buildings N00 and N01, there are some cases of houses collapsing because of structural fragilities of the interface between existing parts and rebuilt parts since the original houses were divided and half of them were rebuilt. For example, a collapsed house in front (N00) and the one at the rear (N01) were originally a single house. It is considered that the rebuilding of only Building N01 caused the outward collapse of N00 at the end of the 2015 disaster.

Fig. 4-2-1 House extended on the 3rd floor (S16). Roof and struts are relocated to one floor higher up. The trace of the past supporting beams is left on the façade.

Fig. 4-2-2 Cracks over the wall under the beam of the extended floor.

Fig. 4-2-3 Cracks are seen on the left side, under the extended floor more than right side where traditional roof style remains (Kirtipur), taken by author on 18th Sep. 2015

Fig. 4-2-4 Example extension of reinforced concrete on the houses (An example from outside of the investigated site)

Fig. 4-2-5 Example of extension of reinforced concrete on upper floor

2. Loss of horizontal rigidity caused by installation of interior staircases after segmentation

Partitions of wooden boards or bamboo were installed in the centre of rooms (for the division of borders of properties) and staircases for each household were constructed after the distribution of property. There are some houses whose horizontal rigidities at the corners were reduced by those works.

3. Fragile structure of the annexes built at the rear

There are some collapsed houses at the rear of the street. We call the generation who contributed to the rehabilitation of Khokana after the 1934 earthquake of 1934 the 'first generation'. Then, the low-rise houses of about 2 storeys were built at the rear of the street (in courtyards) when the children of the second generation (that is, the third generation) grew-up. These houses are jerry-built in comparison with the houses along the street. We thus highlight that the fragile structures of the former houses led to their collapses.

4. Damage to low-rise houses caused water storage tanks falling from high-rise houses

According to the interviewees, the fall of water storage tanks from the high-rise houses on to the traditional low-rise houses led to their damage. The considerable height differences of adjacent houses could be one of the causes of the heavy damage. For example, in one case, the water storage tank on the roof floor of a high-rise house of reinforced concrete (S17) fell onto the roof of the neighbouring traditional low-rise house (S18), causing the upper floor of the traditional house to mostly collapse (Fig. 4-2-12). It is considered this is just one example of many collapses caused by falling water storage tanks.

5. Use of fragile construction materials

As a matter of course, the bricks of the general houses are made more simply and cheaply than those used in royal palace and temple architecture. Even if the outer surface of the brick is constituted of burnt brick, its inside is sun-dried brick. Furthermore, mud mortar (soil made of clay taken from the site) is used inside. We sometimes saw cases of collapses where only the surface have bricks come away because the internal bricks and external bricks were neither unified, nor properly stuck together.

6. Inappropriate construction methods

We also saw some cases of collapses because of inappropriate construction methods. We do not deal any further with these cases in this section.

Reflection 2: Correlation of spatial-formal

Based on the investigation of the townscape in Chapter 2, Section 6 and the reflection on cases of collapses and damage in the paragraphs directly above, we now examine and arrange, in chronological order, the correlation of the spatial-formal transformation of houses along the street and townscape and the disaster damage situation.

1. Before the 1934 earthquake

Every house but four completely collapsed in Khokana in the 1934 earthquake. The foundations of the ground floor of some houses built before 1934 are made of stones taken from the riverside and they remain in situ without cracks even after the 2015 earthquake. It is natural that the earthquake-resistant performance of houses built before 1934 is ineffective given that many of them collapsed in the 1934 earthquake. However, those houses would have some countermeasures and wisdom against the threat of earthquakes. Currently, the hard stones equivalent to those previously used as foundations are no longer used in the foundations of houses, and we cannot see that the replacement construction techniques have been successful. Among the four houses which did not collapse in the 1934 earthquake, S11 and S12 (which were SRU05 at that time, before it was divided in two) have remained on the street. The earliest documents we were able to find date back to 1969 and there is no way to investigate the forms and spaces of the houses before 1934. However, we consider it likely that they were, on the whole, mostly the same as the current houses.

2. Rehabilitation after the 1934 earthquake

The rehabilitation was conducted through the whole of Khokana after the 1934 disaster. The vernacular and beautiful townscape that is inscribed on the UNESCO World Heritage Tentative List was created at that time and its structural framework has remained until now. As residents restored and used their houses where the stone foundations remained even after the disaster, it seems that they rebuilt their houses in same position and form for rehabilitation, in succession to those that stood before the disaster (we now define

Fig. 4-2-6 Example of extension of brick and reinforced concrete on the brick house (An example from outside of the investigated site)

Fig. 4-2-7 Example of disproportional extension. The two houses are not structurally unified. (An example from the outside of the investigated site)

Fig. 4-2-8 Example of damaged houses (N00) neighboring the one with blue balcony (N01)

Fig. 4-2-9 Example of extension after segmentation extension by each heir after property distribution (Kirtipur), taken by author on 18th Sep. 2015

Fig. 4-2-10 The collapsed house at the rearside of N04

Fig. 4-2-11 Water storage tank placed on the roof top (N13)

Fig. 4-2-12 water storage tank of the house (S17) was falled and damaged the roof of low-rise house (S18)

Fig. 4-2-13 Damage of a brick wall after the disaster, with peeling off of surface brick

the generation which contributed to this rehabilitation the 'first generation' on this section). The traditional houses inside the site which keep the original form, being neither divided nor extended, only collapsed due to the fall of water storage tanks from high-rise houses. The structural strengths of the original houses that were built after the 1934 earthquake would be stronger in comparison to the houses before segmentation/extension.

3. The growing up of the second generation's children: the third generation (the first extension period)

There are some cases in which, when the second generation had families and their children (the third generation) were in adolescence, the jerry-built houses were constructed at the rear of the street for second generation families. Thus, the family was separated. However, several houses built at that time collapsed in the 2015 disaster (e.g. the rear of N04), probably because of structural fragility as they constructed with little care given to the structure for their annex buildings.

4. Distribution of property after the deaths of the first generation

The properties of the first generation were distributed to the males of the second or the third generation after the deaths of first generation members. It seemed that, initially, the facades were maintained as before and only the interior spaces were divided vertically. However, some works, such as the installation of interior staircases, caused structural fragilities of the houses, despite those segmentations not change their facades.

5. The growing up of the second generation's household (the second extension period)

The distribution of properties to the second generation (or the third generation) led to the situation where they could either extend or renovate their houses or sites, according to each household's income and status. First, the third floors were extended to enlarge their kitchens when the children grew up and their existing spaces became insufficiently large to accommodate them. We discovered that the extension works only started after 1976 because there are no traces of extensions in the photographs until that year. It should be noted that the houses were extended when the opportunity to restore arose after the partial damage, such as the falls of tiled roofs, caused by the Bihar-Nepal earthquake of 1988. These extensions led to the increasing weights of houses themselves and thus to the expansion of collapses and damage when the 2015 earthquake struck.

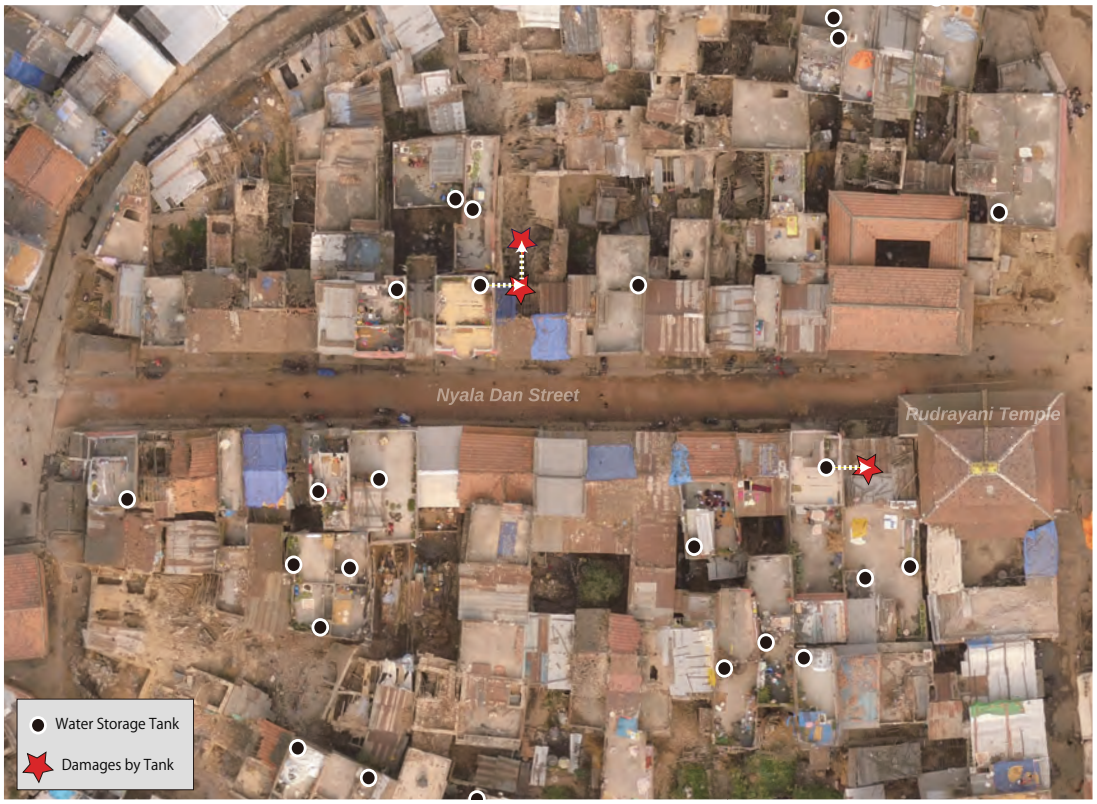


Fig. 4-2-14 Positions of water storage tanks according to the visual survey of photographs and that of actual damages according to the interview (Water storage tanks plotting on the photograph taken after disaster)

6. Further separation of each household of the third generation (the third extension period)

After 2004, the villagers tended to demolish existing houses and then rebuild high-rise houses in cases where there would not otherwise be enough space despite the extension on the third floor or at the rear. This tendency has transformed the townscape of Khokana with immediate effect. Furthermore, the number of residents who do not work as farmers has increased and the difference of income among households is a contributing factor in the frequent trading of the land. Building N07 (or the rear of N04 which was sold), for example, was extended through buying and adding to the land.

Their high-rise houses of rigid structure, constructed of reinforced concrete, may in fact have prevented the collapse of the traditional houses by stopping the tremor of traditional housing adjacent to high-rise houses. Conversely, however, the traditional houses were damaged because of the water storage tanks falling from the roofs of the high-rise houses. Furthermore, the traditional brick houses of fragile structure might have been damaged because of the differences of periods of characteristic oscillation or structural strength. There are also other cases in which the rebuilding of the halves of traditional houses caused the structural disproportion of the remaining other halves, leading ultimately to their collapses.

(3) Conclusion

The issues discussed in this section are only conjectures based on the visual investigation of the buildings and the interviews of the residents: i.e. the above is a hypothesis. However, the transformations of the houses effected by every generation might have led to structural fragility. Moreover, the original structure of traditional houses was not always as fragile as those of the present day. Of course, the structural strength of houses varies according to their architectural forms, their lots, construction methods, and maintenance issues. Therefore, the hypotheses outlined above cannot easily lead to definitive conclusions.

If we express an opinion from the perspective of formal-spatial transformations and the damage investigation inside the houses, it is first necessary not to evaluate earthquake-resistant performance based on the present condition of the structure: instead, we must premise that the current form is the culmination of various transformations. In formulating guidelines about the restoration or rebuilding of the future houses in traditional form, one of the future issues is to conduct an appropriate investigation of the existing traditional houses and to evaluate them in comparison to their past forms.

References:

1. Teizo FUJIWARA, Tadanobu SATO, Tetsuo KUBO, Hitomi MURAKAMI: Survey Report of 1988 earthquake on Nepal-India Border Region, Annual report of Disaster Prevention Research Institute Kyoto University. All Rights Reserved, Volume 32, A, 1989 (in Japanese)

Notes:

1. The epicentre of the earthquake Nepal-Bihar was 10km far from Bhaktapur. However, according to the Annual report of Reference 1, at Bhaktapur, the ancient city of the Katmandu Basin, seven people were dead, 43 people were injured, and 1,750 houses were damaged.
2. All the photographs without specific accreditation were taken by the authors.

4.2.2. Analysis of the extent of damage by exhaustive survey

(1) Outline of survey

We analysed the extent of damage of traditional houses and RC buildings in Khokana through an exhaustive survey. We will analyse the data statistically to comprehend the relation between the characteristics of the buildings and the extent of damage. When the damage was severe and it was difficult to establish the characteristics of the building, we surveyed by posing questions to the residents within the possible range.

(1) Statistic analysis

The extent of damage by type of building structure is shown in Fig. 4-2-15. There are 107 Type A buildings, 172 are Type AB, 80 are Type B, and 234 are Type C. Type AB means that the damage is heavy, with the result that it is difficult to distinguish whether the building type is A or B, as shown in Fig. 4-2-23: in these cases, it is impossible to judge the relation between the degree of damage and the type of building structure. Fig. 4-2-16 shows the damage condition by type of building structure (Types A and B are combined, and compared with C). The degree of damage of Type C (RC buildings) is smaller, and around 95% of these buildings have no damage. We will analyse the traditional houses, Types A, AB, and B, below.

In the traditional houses in Khokana, the buildings extended by brick on the top floor are seen as shown in Fig. 4-2-24. Fig. 4-2-17 shows the disaster damage condition by the presence or absence of extension to the buildings: 165 buildings are non-extended, 77 are extended, and 117 are 'unknown'. Since most buildings with a heavy degree of damage fall within this last category, it is impossible to judge the relation between degree of damage and the presence or absence of extension to the buildings.

Fig. 4-2-18 shows the extent of damage by the position of the buildings: 35 buildings are at the corner of the building complex, and there are 324 others. Buildings at the corner have heavier degrees of damage. It is assumed that the damage to non-corner buildings was decreased by the coupled vibration effect between the adjacent buildings.

Fig. 4-2-19 shows the extent of damage by the number of building storeys: 18 buildings are one-storey, 19 are two-storey, 95 are three-storey, 131 are four-storey, 1 is five-story, and the remaining 95 are 'unknown'. Except for the unknown buildings, the degree of damage of one-storey buildings is the smallest, and the degree of

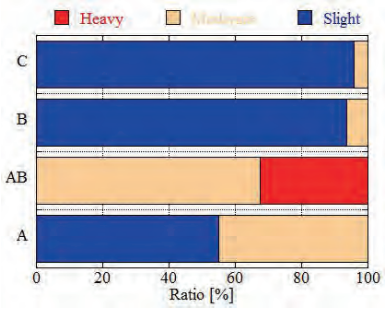
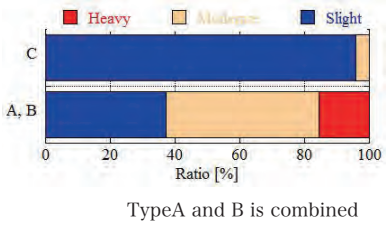


Fig. 4-2-15 Relation between the type of building structure and degree of damage



TypeA and B is combined

Fig. 4-2-16 Relation between the type of building structure and degree of damage

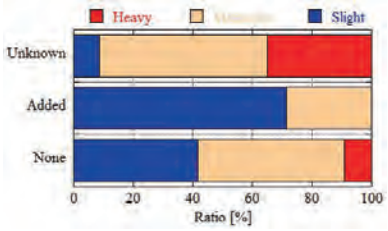


Fig. 4-2-17 Relation between the presence or absence of extension and degree of damage

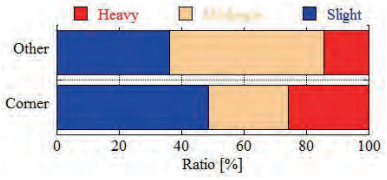


Fig. 4-2-18 Relation between the position of the buildings and degree of damage

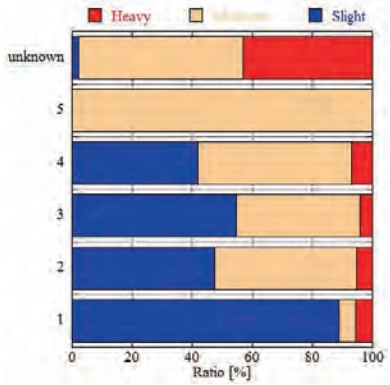


Fig. 4-2-19 Relation between the number of building story and degree of damage

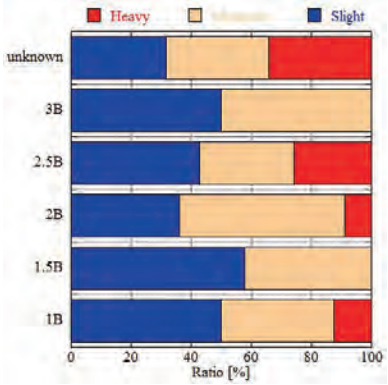


Fig. 4-2-20 Relation between the thickness of the walls at the first floor and degree of damage

damage of 4 or 5 storey buildings is the largest. When the building mass becomes larger by extension of the upper floor, resulting in the compression force acting on the brick walls in the lower storey becoming larger, the shear strength of the joint of the brick wall of the lower storey becomes larger. Conversely, the seismic force acting upon the upper floor is larger due to the amplification effect, and the compression force is smaller. In essence, therefore, the brick walls of the upper floor, with smaller shear strength of the joint, tend to be damaged. It is assumed that the more storeys a building has, the greater the degree of damage that it is likely to suffer.

Fig. 4-2-20 shows the extent of damage by the thickness of the walls of the ground floor. The number of the thickness of the wall means the number of bricks, and the size of one brick is 230mm: eight buildings are 1B, 19 are 1.5B, 216 are 2B, 35 are 2.5B, two are 3B, and 79 are 'unknown'. Most buildings have walls with a thickness of two bricks at the ground floor, so there seems to be no relation between the thickness of the walls of the ground floor and the degree of damage. Since the compression force acting on the top floor is smaller than that on the ground floor, and the shear strength of the joint of the brick walls is smaller than on the ground floor, it is, therefore, assumed that the thickness of the wall of the top floor has larger effect on the degree of damage.

Fig. 4-2-21 shows the relation between the ceiling height and the frontage of the ground floor. The frontage differs from 2 meters to 13 meters by each building, but the ceiling height of the ground floor tends to be around 1.6 meters to 2.1 meters in Types A and B, and 2.2 meters to 2.7 meters in Type C. Fig. 4-2-22 shows that there are no relations between the ceiling height, the frontage of the ground floor, and the degree of damage.

(3) analysis of the extent of damage through the façade drawings

We seek to comprehend the relation between the opening ratio of the building and the aspect ratio (height / width) through the façade drawings of the buildings before the damage. As shown in Fig. 4-2-31, we measured the opening area of the ground floor by sight, and roughly estimated that of the upper floor and the collapsed area by the scale of the drawings. The façade drawings before the damage

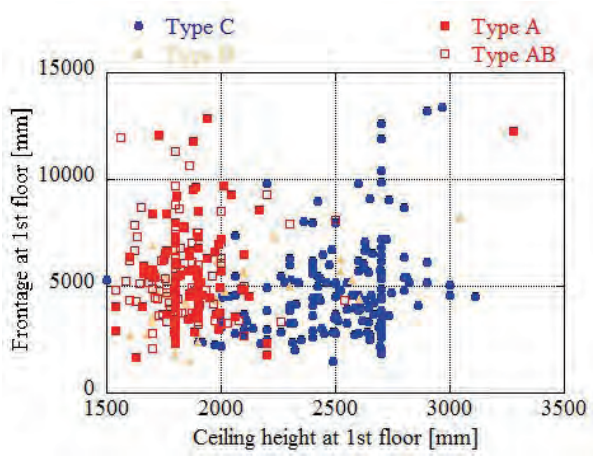


Fig. 4-2-21 Relation between the ceiling height and the frontage at first floor

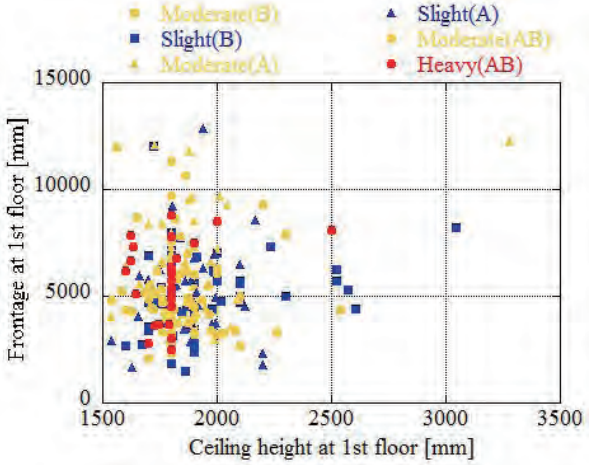


Fig. 4-2-22 Relation between the ceiling height, the frontage at first floor, and degree of damage

Fig. 4-2-23 Heavy damage of the building Type AB

Fig. 4-2-24 Extension at the fourth floor

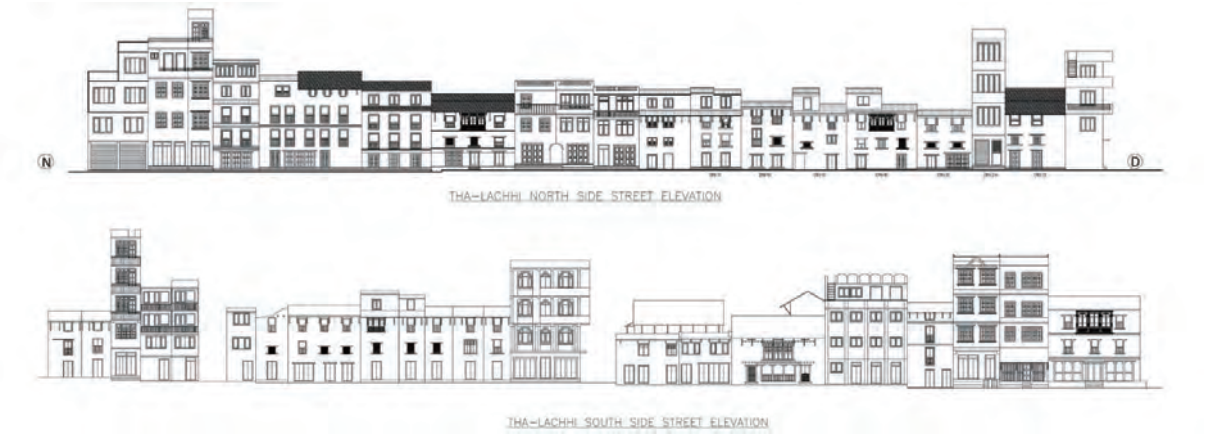


Fig. 4-2-25 TAH LACHHI STREET

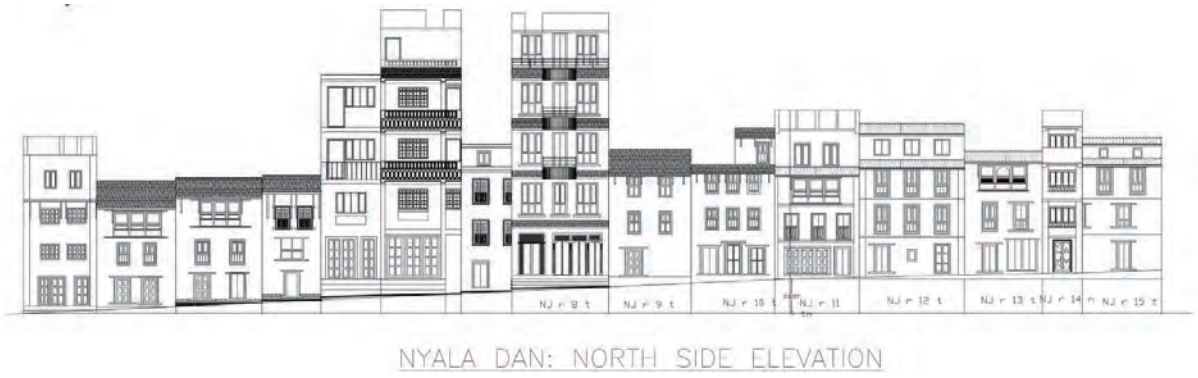


Fig. 4-2-26 NYALA DAN STREET

Fig. 4-2-27 TAH JHYA STREET 2

Fig. 4-2-28 TAH JHYA STREET

of Tah Jhya Street, Tah Lachhi Street, and Nyala Dan Street are shown in Figs. 4-2-25, 26, and 27. We analysed 49 buildings which are shown in these drawings except Type C.

Fig. 4-2-29 shows the extent of damage by type of structure: 23 buildings are Type A, 21 are Type AB, and five are Type B. Fig. 4-2-30 shows the relation between the ratio of opening at the ground floor and that of the top floor. The buildings of Type B tend to have an extended top floor, and have a smaller ratio of the opening of the top floor than that of the ground floor. As shown in Pict. 4-2-24, the ratio of opening of the ground floor is almost equal to that of the top floor in most Type A buildings.

Fig. 4-2-31 shows the relation between the opening ratio and the aspect ratio of the ground floor, and Fig. 4-2-32 shows that of the top floor. The opening ratio of first floor is distributed from 20% to 60%, and that of top floor is from 10% to 40%. The aspect ratio is distributed from one to two in most buildings. The relation between the opening ratio or the aspect ratio and the degree of damage is not seen, so it is assumed that there should be other intervening factors.

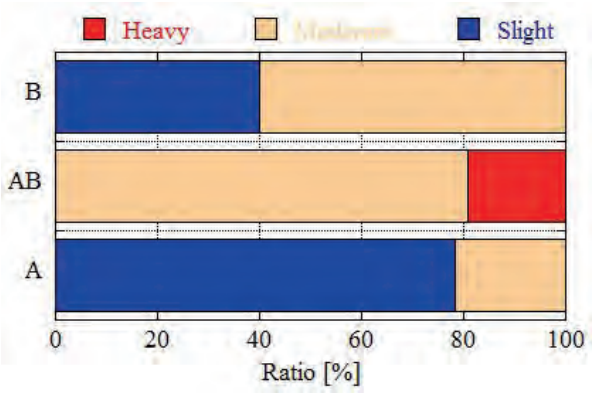


Fig. 4-2-29 Degree of damage of the target buildings

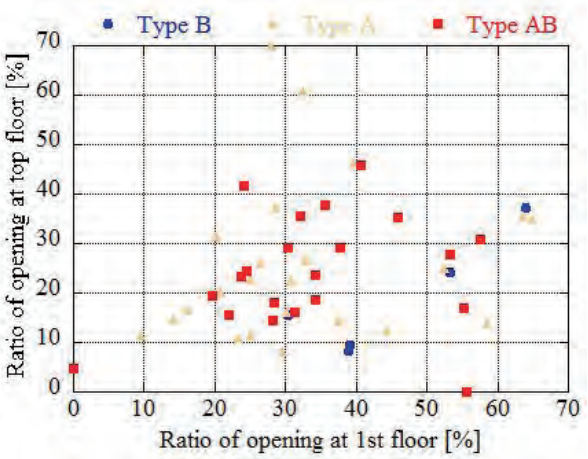


Fig. 4-2-30 Relation between the ratio of opening at first floor and that at top floor

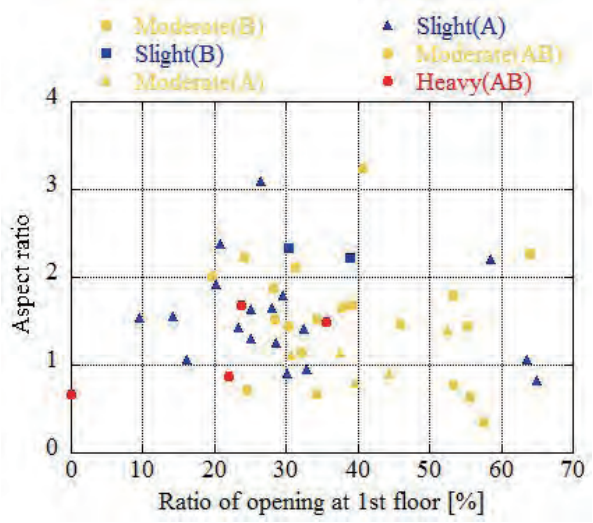


Fig. 4-2-31 Relation between ratio of opening and aspect ratio at first floor

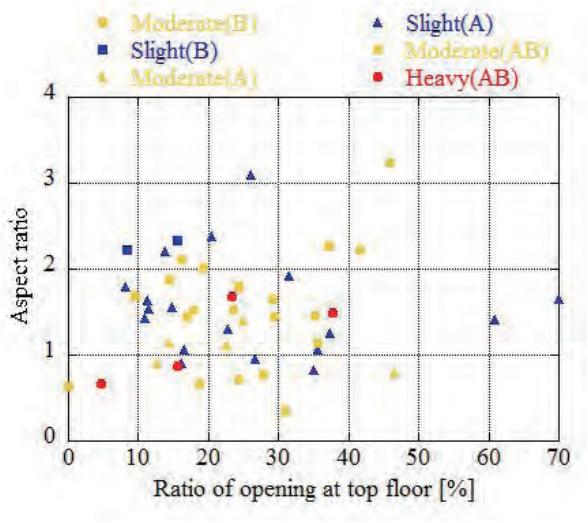


Fig. 4-2-32 Relation between ratio of opening and aspect ratio at top floor

4.3. Change of Living Environment After the Earthquake

4.3.1. Temporary Shelters

(1) Outline of the survey

Many buildings in Khokana Village were damaged; even in cases where residential houses have not been completely destroyed, there are many homes which, due to safety problems, are impossible to live in. Consequently, many residents have constructed and are living in temporary dwellings inside and around the village. In this section, by comparing aerial photographs from before and after the earthquake and conducting an on-site investigation, we have identified the places where temporary housing has been constructed and examined the (temporary) changes to the village structure.

The contents of this section are based on the on-site survey conducted in November 2015 (observing and interviews with residents) and the comparison of aerial photographs taken before and after the earthquake.

(2) Conditions in Khokana during the earthquake

Because the earthquake on 25 April 2015 occurred during the day, many residents were out doing farm work and thus escaped the damage from collapsed buildings; however, those who were inside buildings (particularly the elderly and children) were victims of this damage (as stated above, the victims comprised nine dead and 28 wounded). The local youth club is said to have taken a leading role in performing rescue work. At the time of the disaster, people in the village feared the collapse of buildings and evacuated to the wide main street. There were also many people who evacuated to the safer bus park where there are no surrounding buildings. On the day of the earthquake, there was a health club being run by the youth group and we were told that around 200 people evacuated there.

After the earthquake, an emergency meeting was held in the community. After nightfall, refugees were moved to schools and factories on the edge of the village judged to be undamaged and safe. The disaster victims were divided into several groups and were mainly assigned to refuge shelters according to their communities.

(3) Construction of temporary residences

Around one month after the earthquake, individuals and communities were allotted shelter spaces and materials. In many cases, temporary residences were constructed by the residents themselves with building materials such as zinc-coated steel mainly provided by the Nepal Government and NGOs (such as the Fondation de France). We were told that there are two types of land on which these temporary residences have been built: fields owned by disaster victims or their relatives and land borrowed from others by paying land rent.

Through this survey, it became clear that temporary residences were mainly built on vacant land in and around the village. In particular, the majority of temporary residences are constructed on the edge of the village, where the risk of secondary damage due to buildings collapsing is small. Based on the comparison of aerial photographs taken before and after the earthquake and the on-site investigation, the temporary residences are indicated as having been constructed around the village after the earthquake in Fig. 4-3-3.

Fig. 4-3-1 The larger area for temporary housing at the vacant lot of the west side of the village (The road on the right side of this photo is a part of the ringroad)

Fig. 4-3-2 Temporary housing in the northern settlement (The trees on the back side of the photo surrounded the village before the disaster)

(4) Issues Surrounding Changes in the Structure of the Village due to the Earthquake and the Recovery

Over 300 temporary structures are thought to have been constructed after the earthquake around the perimeter of the village alone. Many of these are built on vacant land for farming or farming related work around the village where there is comparatively little incline. Furthermore, part of the forest land surrounding the village is being used for temporary residences, and the extent of this forest land is consequently decreasing. Consequently, the clear division between the village and the terraced paddy fields is being lost, and the temporary residences are temporarily expanding the territory of the traditional village. In addition, the farm roads outside the village are being extended as access roads to these temporary residences around the perimeter of the village, forming a ring road around the village. It is possible that the temporary residences will become permanent residential land; in our opinion, it is necessary to consider implementing rule-making for future development of the area surrounding the village.

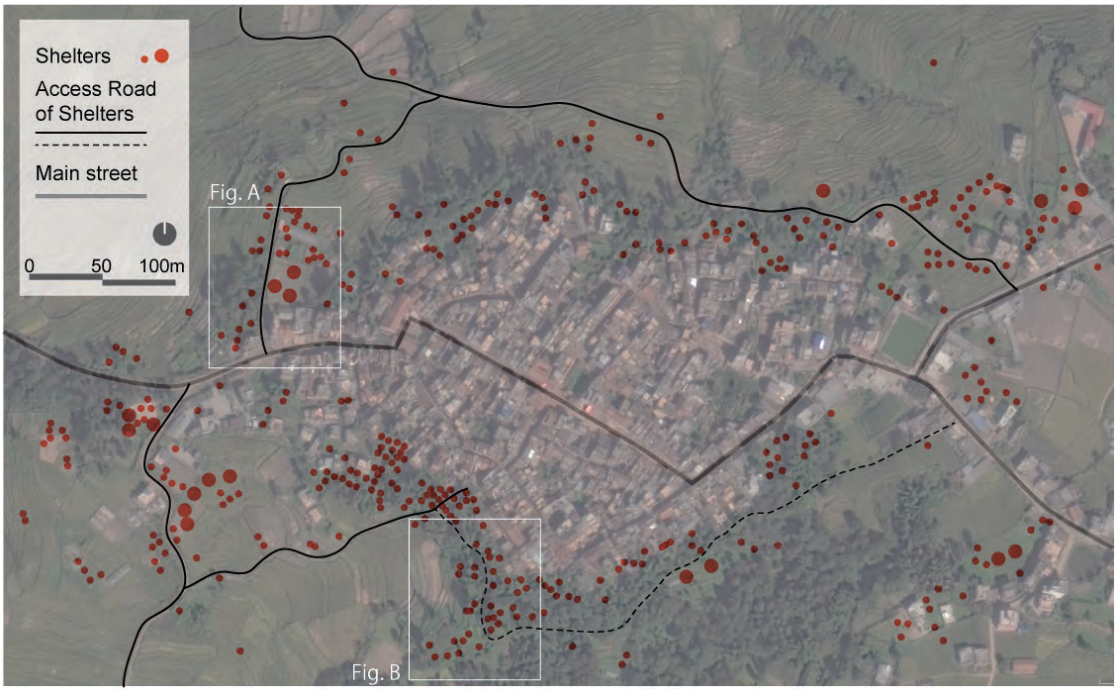


Fig. 4-3-3 Distribution of the shelters in the periphery assumed by aerial photograph before (Taken on 25 Oct. 2014) and after the disaster by Google Earth

Fig. 4-3-4 Shelters in the periphery of the village (Partially enlarged view of Fig. A)

Fig. 4-3-5 Shelters in the periphery of the village (Partially enlarged view of Fig. B)

4.3.2. Residents' Intentions about Rebuilding Houses after the Earthquake

(1) Outline of the Survey

After the April 2015 Nepal earthquake (the Gorkha earthquake), interview surveys of local opinions about rebuilding houses was conducted. The survey's aims were to detect problems and tendencies about rebuilding, and to estimate its influences on changes of the townscape.

Interview surveys were conducted from 10 to 19 August 2015, and from 25 December 2015 to 1 January 2016. Four areas were determined for the surveys (Chorcha and Suryamadhi in Bhaktapur, Chyasal in Patan, and Khokana), and a total of 34 people agreed to be interviewed. The second interviews were principally conducted with the same people or their families (Two of them were unable to attend the second interview).

The methods of the survey were investigating the appearances of buildings and conducting interviews.

From the buildings' appearances, 1) construction and 2) suffered damage were investigated. Additionally, interviews were conducted as needed to complement this information.

(2) Study about intention for rebuilding in Khokana

In this section, the intentions of residents for rebuilding and the changes to their intentions will be studied, focusing especially on Khokana.

In Khokana, the interviews were conducted with eight residents on 12 and 15 August 2015 (the first investigation), and on 27 December 2015 (follow-up investigation).

Tab. 4-3-1 summarises the results. The columns are for each of the eight interviewees (K-1~K-8) and rows are for the contents of the interviews. Two cells of answers to one question means that the interviewee's answer changed (arrows in the same row mean the answer did not change). Unfortunately, the interviewer did not meet one interviewee ('K-3') for a second interview.

The houses of six interviewees had collapsed completely, and five of them lived in temporary houses as at August 2015. One of the other interviewees lived in another site, and the other lived in the house on site while repairing it. At the time of the second interview, three people had returned to their houses on site having become accustomed to living there and because of their job.

Regarding land ownership, six have single (sole) ownership of their homes, while only two were joint owners. In other areas, especially in Bhaktapur, land ownership is more complex and one of the big problems that is interfering with reconstruction and rehabilitation.

In comparison with the other sites surveyed, land ownership did not appear to be a particular problem for rebuilding in Khokana. Such a state is different from that in the downtown area.

All of the interviewees hoped to rebuild on the site. Some of them tried to rebuild by seeking funds from the government's earthquake-related special loan and by selling their land, while others maintained their houses by allocating maintenance assistance while living there. Nevertheless, one interviewee did not consider funding because the problem of land ownership did not admit this solution (K-6).

Regarding the method of rebuilding, at the first interview, two of the interviewees hoped to rebuild using traditional mixed-structures with bricks and wood, while another two planned to maintain their current traditional houses. The number who hoped to rebuild by RC structure increased by two from the first to the second interview, becoming 5 in total.

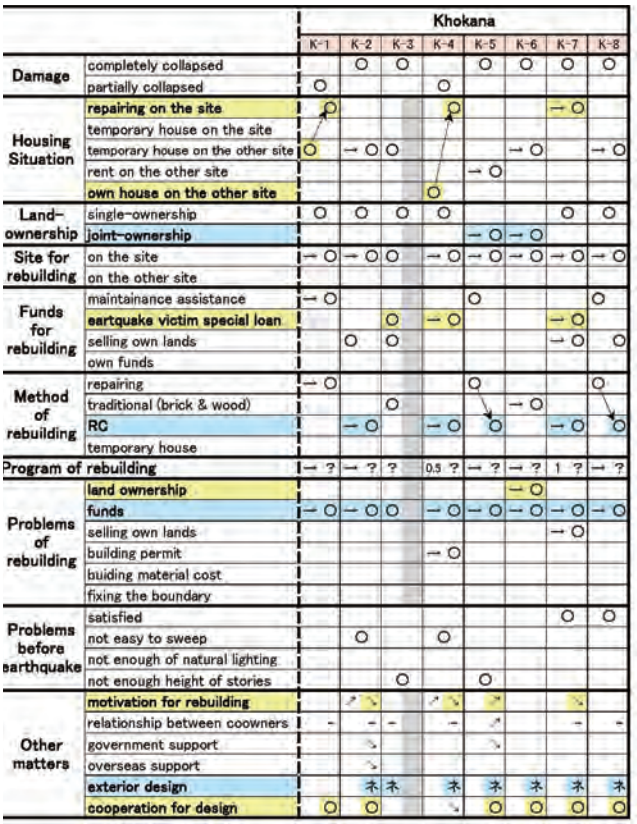
Nevertheless, we discovered that not everybody could aim for rebuilding for the future. The interviewee who had planned to rebuild in half a year or one year at the first interview had been forced to abandon this prospect by the second interview. The reasons for this included delay securing building permission from the government, having no plan for sourcing funds (e.g. by selling land), and having been unable to obtain specific details about the loans provided by the government (because of mortgage problems, it was even unclear whether the money could be borrowed). Motivation for rebuilding tends to diminish with the elapse of time. Moreover, both expectations of and disappointment with foreign NGO groups co-existed.

Moreover, two were satisfied with the traditional living space, while others had dissatisfaction with hardness to sweep or lowness of height of stories (two each). The latter intentions will probably affect the rebuilding.

(3) Summary

In Khokana, 'The Khokana Reconstruction and Rehabilitation Committee' was established, and local young people have played a central role as members of the committee to organise inhabitants for reconstruction by removing rubble, financing for concrete

Tab. 4-3-1 Survey Results



reconstruction, and holding meetings. Moreover, Khokana had another committee which acted independently. At the second interview, it was said that these two committees were trying to integrate and act together.

Young architects and civil engineers are members of the Khokana Reconstruction and Rehabilitation Committee, and they have created reconstruction plans of the ceremony hall and produced future images of the townscape. They acquired funds by exhibiting their plans and images at local meetings. Many inhabitants had high hopes on the activities of the committee, which do not depend on the government. Therefore, most inhabitants tend to follow the committee's opinions and policies.

At the interviews, many people hoped to cooperate in the design of the townscape, and to rebuild their houses with the Newar style exterior design (written ' ネ ' in the row of exterior design in the Tab. 4-3-1). These are also the results of reconciliation of differences among local opinions by the committee. At the same time, they demonstrate expectations about the fund-raising capabilities of the committee.

A local meeting was held a few days before the second investigation. The committee was raising funds for demolishing buildings, and its recommendation to rebuild with RC structure was announced there. This seems to be reflected in the results of the second investigation. Conversely, were some inhabitants had the realistic opinion that it was difficult to raise funds to unify the exterior designs of all the houses, and they emphasised their personal rights by calmly judging the committee's strong opinions and activities.

There are great problems concerning how to raise funds, how to solve the land ownership issues, and in selecting the method for rebuilding houses, in a situation that requires immediate reconstructions and improvements to townscapes following a natural disaster. During the investigations, we witnessed efforts towards reconstruction and changing intentions for rebuilding, while positive looks or appreciations on their own way of life that had formed their life space in Khokana were not heard clearly during the interviews.

In the reconstruction of Khokana, an appropriate process is required to pay due attention to and share the importance of the way of living that the Newar established in Khokana; only in this context should debate over the design of each house and of the townscape ensure.

Acknowledgement:

This article is the result of investigations as a part of the JPS KAKENHI (Specially Prompted Research) "General Investigation of the 2015 Nepal Earthquake and its Disaster" and of sharing information with the Project for International Contribution to Cultural Heritage Protection (Exchange of Experts "Investigation of Damage Situation of Cultural Heritage in Nepal").

4.4 Survey of Changes Post-earthquake

(1) Overview of survey

Using pictures that have each building facing the main street recorded with an ID number (Ex: A001) as a basis and comparing them to their present state through an on-site survey, we have recorded changes for each building. We have divided the changes for buildings into the 6 classifications below, and recorded the phase of change using that index (Fig.4-4-3). The survey recorded changes over 3 years, in 2016 (1-year post disaster), June of 2017 (2 years post disaster), December of 2017 (2 and a half years post disaster) and August 2018 (3 years post disaster).

Phase 0: No change

Phase 1: Small-scale repair of affected building

Phase 2: Repair through dismantling of building roof / upper floors

Phase 3: Dismantling / removal of building

Phase 4: Building removed and rebuilt with traditional construction methods

Phase 5: Building removed and rebuilt with non-traditional construction methods

Additionally, we interviewed owners who rebuilt with reinforced concrete after the disaster to get background information on the rebuilding.

(2) Observation Result

1. Overall

We confirmed changes across a total of 233 houses, with 60 at the first year and a half, 28 more at 2 years, 53 more at 2 years and a half and 92 more at 3 years. Fig.4-4-1 shows this transition in change. Changes are increasing more in recent years, and we surmise that the right shoulder will continue to transition upwards.

2. Acceleration of reconstruction with reinforced concrete

It became clear that a total of 86 houses were reconstructed with reinforced concrete, with 7 at the first year and a half, 20 more at 2 years, 16 more at 2 years and a half and 43 more at 3 years. In particular, this year (3 years after), the number of houses being rebuilt has risen dramatically. We surmised reinforced concrete reconstruction will continue, given phases 2 and 3's inevitable transfer to phase 5 (Fig.4-4-2).

3. From spaces shared with family to those of sole ownership, reconstruction with a narrow span and changes as a group (spatial reorganization)

As families would take one building and divide it vertically, reconstruction is being done independently at an uneven pace. In

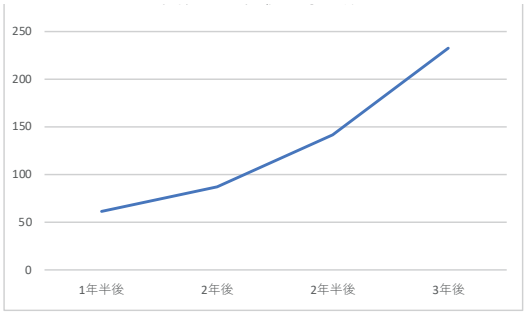


Fig. 4-4-1 Transition of numbers of traditionally constructed houses which changed its formation after the eatrthquake

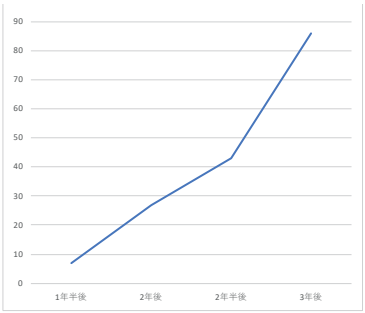


Fig. 4-4-2 Transition of numbers of rebuilded houses with RC

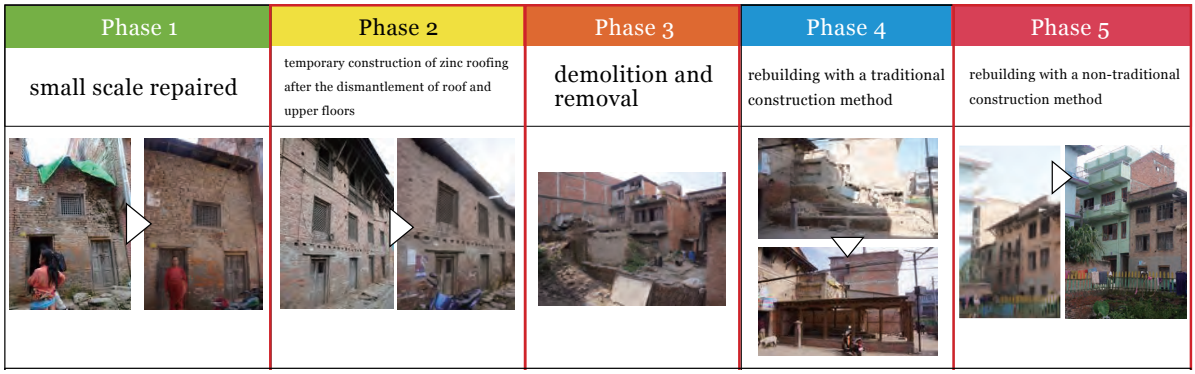


Fig. 4-4-3 Classification of change of buildings

construction with a narrow span, space efficiency drops as staircases will be set alongside the living area, however, we surmised that this would increase to reflect changes in social structure like the nuclearization of the family.

Residents have a tendency to work with their neighbors and keep pace with them when it comes to working on affected buildings. Concretely grasping neighborhood units like Tole (Twa)(A social, spatial unit in traditional villages that largely corresponds to the local community)[1], which became clear from the survey conducted last year, and reflecting them in the creation of the coming restoration/conservation plan will be very important. In this year's survey in 2018, Nyaja Dan Twa, the main street, has had reinforced concrete reconstruction occur on 7 buildings. Other blocks have also seen an increase in reconstruction work.

(3) Trends from interviews with owners who rebuilt with reinforced concrete after the disaster

In surveys done in November, and January and February of 2019, we performed a provisional interviews with owners who had rebuilt with reinforced concrete after the disaster was conducted to find details into the background of reconstruction. We received information from 13 houses , but we plan to conduct continuing research from next year to get a better grasp of the actual situation. Trends show that houses with narrower frontage are more likely to secure extra rooms and increase the number of floors. Additionally, we saw 2 houses that reconstructed by extending the existing reinforced concrete structures in their backyards. The ground floor is used as a passageway or for business, and the second floor and up is used as a living space. Or, the second floor is used as a rented room in houses with 3 floors or more, and the top floor has a dining kitchen and terrace established, making use of open-air space.

(4) Summary and Thoughts

Details of changes became clear through this survey. At present, what can be seen is that traditionally constructed buildings that have been reconstructed have all used reinforced concrete, greatly changing the look of the townscape. Additionally, things were dissembled for economic reasons, like roofs or top floors that had been disassembled and replaced with tin to use as storage or as kitchens and temporary dwellings that were being used as sleeping areas. The majority of citizens were looking to newly construct the basic design of their house at some point in the future. Aided by the notion that reinforced concrete buildings are safe as they are earthquake-proof, it's easy to surmise that traditionally constructed buildings will continue to disappear. On the other hand, we also heard opinions that people would look into reconstruction methods that followed neighborhood and VDC rules, which made it possible to surmise that there was still a strong sense of community where the whole was greater than the one.

Note:

1. Pant Mohan, Shuji Funo: Spatial structure of the Jyapu community Quarters of the city of PATAN, KATHMANDU VALLEY, Architectural Institute of Japan's Journal of Architecture and Planning, 527, pp.177-184, 2000.1

Fig. 4-4-4 Change of houses (2016)

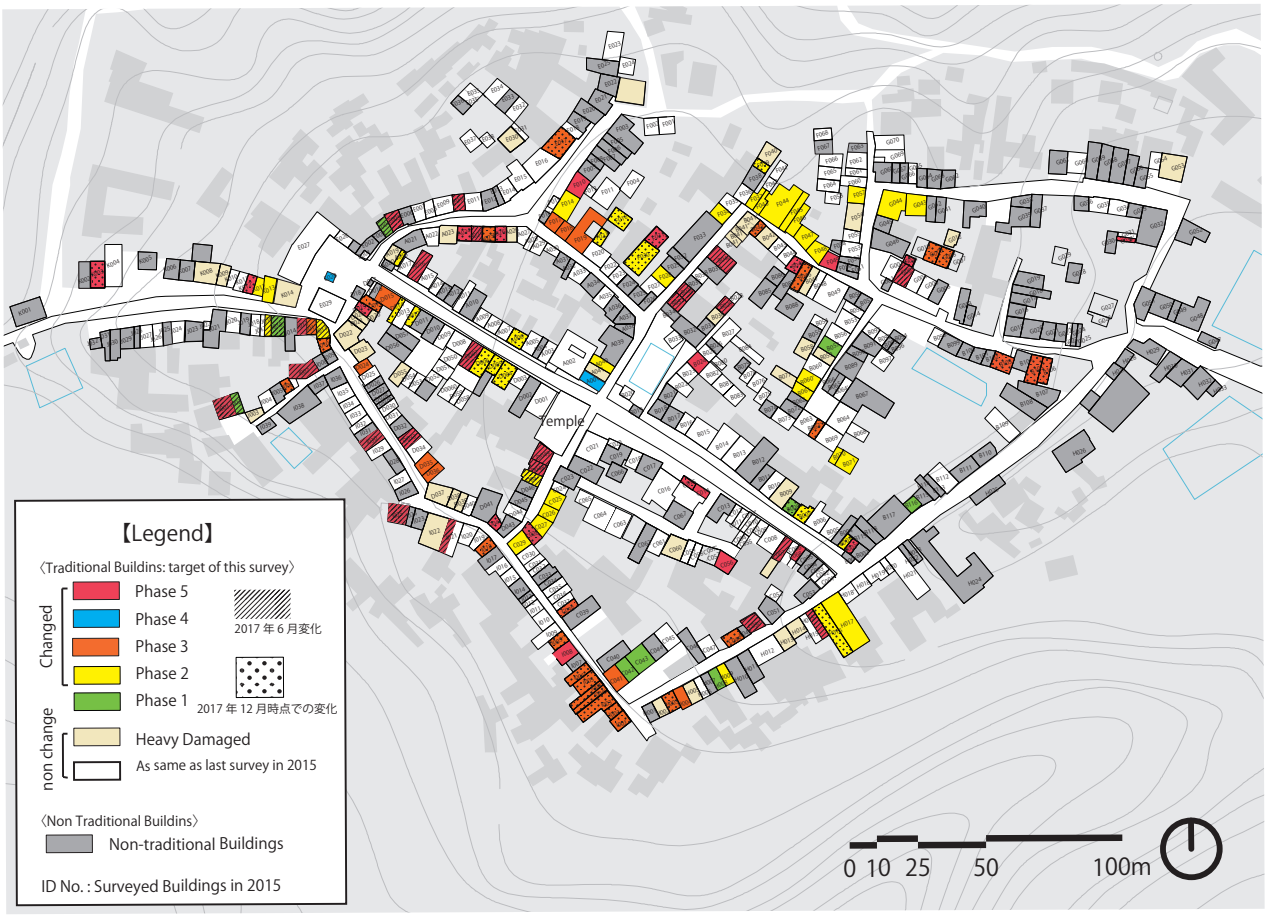


Fig. 4-4-5 Change of houses (2017)

Fig. 4-4-6 Change of houses (2018)

5. Plan for Conservation

5. Plan for Conservation

5.1. Basic Plan for Preservation and Improvement

(1) Basic policy for preservation and development

Faced with the rehabilitation and reconstructing of buildings damaged by the earthquake, one should be mindful of improving the life environment of the residents and modernisation. This plan utilises the characteristic features of the village, preserves the group of traditional buildings, the cultural landscape, and the surrounding environment; while at the same time designing an area for development.

Framework of the preservation and improvement plan

Dividing the former Khokana VDC into the three areas of 'Cultural Landscape', 'Historical Settlements', and 'Harmony Area', a Preservation plan will be established for 'Cultural Landscape' and 'Historical Settlements', and a Development plan will be established for the 'Harmony Area' (Fig. 5-1-1, and 5-1-3).

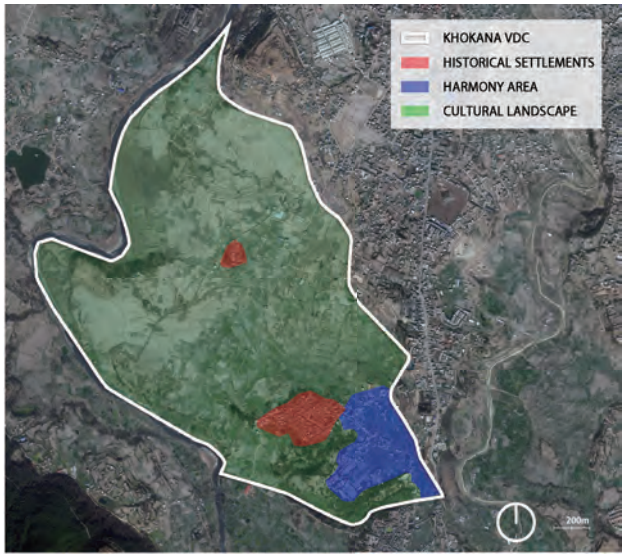


Fig. 5-1-1 Area of the preservation and improvement plan (Bing map modified by author)

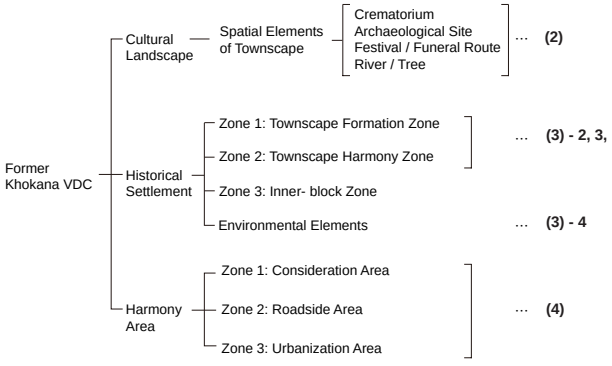


Fig. 5-1-3 Framework of the preservation and improvement plan

(2) Cultural Landscape

1. Basic policy for preservation

To maintain the historical and cultural value of the 'Cultural Landscape', the spatial elements of the landscape, which are the direct source of this value, should be preserved. Moreover, not only the value of the spatial elements of the landscape, but also that of the surrounding environment should be maintained. Land use should be maintained at its current level and new buildings should not be built in that area.

2. Spatial elements of landscape

Elements identified as conveying the characteristics of the region's cultural value in the area of 'Cultural Landscape' should be designated as spatial elements of the landscape (Tab. 5-1-1, and Fig. 5-1-2).

Fig. 5-1-2 Distribution of spatial elements of landscape (Bing map modified by author)

Tab. 5-1-1 Spatial elements of landscape

	Site No.	Category
Cultural Landscape Constituent Elements of Landscape	38	Waterway
	39	Pond
	40	Pati
	41	Open space and others
	42	Pati and others
	43	Pati and others
	44	Shrine and others
	45	Pati and others
	46	Water space and others
	47	Temple
	48	Shrine
	49	Crematory
	50	Cremation route
	51	Festival route

(3) Historical Settlements

1. Basic policy of preservation plan

The objective of the plan is preserving the traditional townscape created by the Newari houses and the cultural and religious elements of the settlement through improvement, façade beautification and respectful reconstruction. The plan tries to achieve both the modernization of the lifestyle with the preservation of the townscape. 'Historical Settlements' are divided into two zones: Zone 1 in particular actively forms a traditional townscape, while Zone 2 aims to create a townscape that harmonises with Zone 1.

2. Explanation of ZONE 1/ ZONE 2, traditional buildings/semi-traditional buildings

1) ZONE 1: Townscape formation zone

The 'Townscape Formation Zone' is the area where, at the present time, a continuous historical townscape has been maintained; consequently, it should be a selectively rearranged townscape. Buildings within ZONE 1 that have particular historical importance and a small degree of damage will be designated 'Traditional buildings' (Tab. 5-1-2).

Fig. 5-1-4 The area of Historical Settlements (Bing map modified by author)

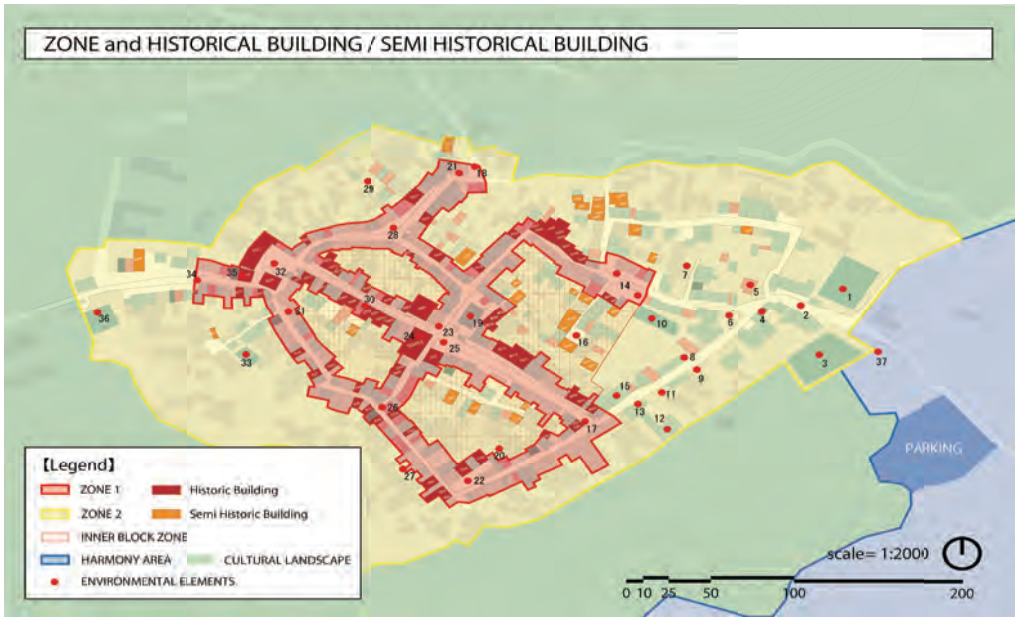


Fig. 5-1-5 The boundaries of Zone 1 / Zone 2 and distribution of Historical buildings / Semi-historical buildings

2) ZONE 2: Townscape harmony zone

The 'Harmonised Townscape Zone' is the area where, while the continuity of the historical neighbourhood is weak, a harmonised townscape of the neighbourhood is desired for the future. Buildings within ZONE 2 that are of particular historical importance and that have a small degree of damage will be designated 'Semi-traditional buildings' (Tab. 5-1-3).

3) Zone 3: Inner -block zone

The 'Inner - Block zone' is the area located ZONE 1 to the backside of buildings of Patios, inner streets, and wells are the spaces that support the daily lives of the village's inhabitants. They are, therefore, important for understanding the development of the settlement. In this research period, we could not conduct a detailed survey inside the blocks. This remains as a future issue to understand the space and the methods to preserve it.

Tab. 5-1-2 List of traditionally constructed buildings

No.	Building No.	Usage	No.	Building No.	Usage	No.	Building No.	Usage
1	-	Temple	24	C030	House	47	F020	House
2	A002	Guthi Building	25	C035	House	48	F028	House
3	A003	House	26	C043	House	49	F034	House
4	A006	House	27	C045	House	50	F037	House
5	A009	House	28	C052	House	51	F043	House
6	A014	House	29	D003	House	52	F044	House
7	A015	House	30	D004	House	53	F045	House
8	A016	House	31	D005	House	54	F046	House
9	A030	House	32	D006	House	55	F047	House
10	B003	House	33	D008	House	56	F048	House
11	B005	House	34	D009	House	57	F049	House
12	B006	House	35	D012	House	58	I002	House
13	B013	Museum	36	D015	House	59	I003	House
14	B014	House	37	D019	House	60	I005	House
15	B015	House	38	D035	House	61	I016	House
16	B022	House	39	D040	House	62	I018	House
17	B023	House	40	D047	House	63	I020	House
18	B024	House	41	D048	House	64	I027	House
19	B092	House	42	E004	House	65	I030	House
20	B093	House	43	E017	House	66	J012	House
21	C001	House	44	E027	Guthi Building	67	J015	House
22	C002	House	45	E029	Guthi Building	68	J022	House
23	C021	Municipality Office	46	F010	House	69	K014	Oil Mill

Tab. 5-1-3 List of semi-traditionally constructed buildings

No.	Building No.	Usage	No.	Building No.	Usage	No.	Building No.	Usage
1	B027	House	15	C063	House	29	G008	House
2	B029	House	16	D035	House	30	G035	House
3	B054	House	17	D040	House	31	G043	House
4	B056	House	18	D058	House	32	G069	House
5	B060	House	19	D059	House	33	G070	House
6	B061	House	20	E023	House	34	I020	House
7	B063	House	21	F020	House	35	I027	House
8	B070	House	22	F030	House	36	I030	House
9	B071	House	23	F059	House	37	J002	House
10	B097	House	24	F060	House	38	J012	House
11	C054	House	25	F061	House	39	J015	House
12	C055	House	26	F062	House	40	J022	House
13	C056	House	27	F065	House	41	K004	House
14	C061	House	28	F066	House			

3. The contents of the preservation plan by zone

The preservation plan for the 'Historical Settlements' is summarised in Tab. 5-1-4 below in accordance with the two zones and the types of current buildings (Traditional house and RC building).

1) Zone 1

① Traditional buildings (belonging to slight and moderate in type A and slight in type B as described in Chapter 4, Section 1)

Traditional building repairs will be mainly limited to maintaining the exterior appearance and will treat maintaining the current condition as its basic approach. Furthermore, restorative repair will be considered for buildings that have undergone renovations or repairs unsuited to traditional forms.

② Standards for non-traditional buildings

Rebuilding (new building), extensions, repairs, or colour changes will follow the standards below and actively strive to form a townscape.

• Traditional houses damaged by earthquake (Type B moderate)

As much as is possible, existing parts will be preserved and utilised, and restoration will be performed on earthquake-damaged houses using traditional construction methods.

• Existing RC buildings (Type C)

A colour guideline will be created and used as a basis for remodeling. For other elements, an overall landscaping plan will be considered.

• Newly built houses (Type A, B heavy)

Construction Method

Use traditional construction methods

Roof

Use a sloped tiled roof as a rule and angle braces

Number of Floors

Three and half floors, in consideration of the continuity of (5) Tourism development plan

Ceiling Height

Adjust with other buildings to form neighbourhood townscape

Extension

Not to be conducted

Exterior Wall

Use brick and follow the colour guideline

Windows

Use wooden window frames, and a guideline is also necessary with respect to window frame colour and window glass to avoid damaging the townscape

Door

Use wood, and follow traditional forms for color and shape.

Platform

Make allowances for the continuity and harmony of the neighborhood

2) ZONE 2

① Semi-traditional buildings

Semi-traditional buildings will be treated according to the same

Tab. 5-1-4 The contents of the preservation plan

	ZONE 1	ZONE 2
Traditional Building	The basic approach to traditional buildings will be to maintain their current condition, and with regard to buildings damaged by earthquake, repairs using traditional construction methods will be conducted in order to restore them. Traditional construction methods will also be used for rebuilding.	Semi-traditional buildings will be preserved to the extent possible. It is desirable that other earthquake damaged traditional buildings be repaired using traditional construction methods.
RC Buildings	Use color as the basic approach for landscaping concerning existing RC Buildings and lead them in the direction of traditional buildings when rebuilding.	Draw up design guidelines.

standards as traditional buildings.

② Standards for other buildings

Rebuilding (new building), extensions, repairs, or colour changes will maintain similarity or harmony with the exterior view of traditional buildings and will follow the standards below.

Construction method

Using traditional construction methods is desirable, under conditions that fulfil the standards below, RC is also permissible

Roof

Install sloped tiled roofs along the street and angle braces

Number of floors

The maximum number of floors shall be four, in consideration of the neighbourhood townscape

Ceiling Height

Harmony with Semi-traditional buildings will be prioritised, in consideration of the neighbourhood townscape

Extensions

Extensions are permissible if the entire building, including the extension, has four floors or fewer, but consideration of the townscape is necessary for the shape and colour of the extension

Exterior Wall

Use brick and take into consideration the harmony with the neighborhood townscape when choosing a color.

Window

As much as possible, wooden window frames should be used. It is also necessary to ensure the window frame colour and window glass do not damage the atmosphere of the neighbourhood. When using metal on the window frame, arrangements must be made so that the position and colour of the windows do not stand out.

Door

Use wood and take into consideration the neighbourhood townscape when choosing colours and shapes. When using metal on the doorframe, arrangements must be made so that the position and colour of the doors do not stand out.

Balcony

Items that seriously impede neighbourhood continuity, such as outside attachments to the outer walls facing the streets, are impermissible. Balconies may be installed on the rooftops and behind buildings provided they do not affect the scenery of the streets.

Platform

Considerations will be made for maintaining continuity and harmony with the neighborhood

4. Environmental elements

Concerning environmental elements, the basic approach will be to maintain the current conditions; however, with respect to buildings that have been damaged by the earthquake, traditional construction methods will be employed to perform repairs. Furthermore, for work performed around environmental elements (that impacts upon environmental elements), a system for obtaining the permission of

Tab. 5-1-5 List of environmental elements

Site No.	Category	Site No.	Category	Site No.	Category
1	Pond	14	Waterspace, open space, alter, and shrine	26	Water space
2	The site of Dhoka	15	Mustard oil mill	27	Well and open space
3	Pond	16	Shrine	28	Open space, well, stupa, pati, and others
4	Water space	17	Well, shrine, and pati	29	Open space, well, stupa, and water space
5	Mustard oil mill	18	Shrine, pati, water space,	30	Temple
6	Well and water space		and the site of Dhoka	31	Water space
7	Well	19	Pond, water space, shrine, and pati	32	Open space, well, shrine, pati, Duthi,
8	Shivalinga	20	Well		water space, and others
9	Water space	21	Mustard oil mill	33	Pond
10	Pond	22	Open space	34	The site of Dhoka
11	Trees	23	Open space, pati, and others	35	Mustard oil mill
12	Temple	24	Temple	36	Pond and pati
13	Water space	25	Stupa and others	37	Shrine

the local administration and residents' organisations is necessary.

(4) Harmony Area

1. Basic policy for improvement and development

In addition to planning a unified sense of harmony between the 'Historical Settlements' and 'Cultural Landscape' to be preserved as a historical village, the 'Harmony Area' will be established as an area where planned development can be conducted that makes consideration for future development.

In present day Khokana, there is concern that the population increase that is expected to continue in the future will worsen the living environment; the reconstruction of living environments for those residing in temporary housing due to earthquake damage is also an urgent issue. To tackle these issues while simultaneously maintaining the historical village, a 'Harmony Area' will be established as a development plot that maintains harmony, avoiding negatively impacting the historical townscape in the immediate vicinity of the village and accommodating housing demand in a planned manner.

2. The framework of improvement and development

The 'Harmony Area' is divided into three zones that are each oriented differently toward improvement and development (Fig. 5-1-6). Below, we provide an overview of each zone.

1) ZONE 1: Consideration area

This will promote improvement and development in consideration of future tourist development and as an entrance to the 'Historical Settlements' from Khokana Road that makes considerations for the townscape of the 'Historical Settlements'. Building colour, design, and height will be regulated to avoid impeding the townscape woven together by the traditional buildings of the 'Historical Settlements' and the landscape of the terraced paddy fields to the north designated as 'Cultural Landscape'.

2) ZONE 2: Roadside area

This will define the road to Bungamati, with which Khokana shares a deep historical and cultural relationship, as an important axis that promotes development while taking the townscape into consideration. Building colour, design, and height will be regulated to maintain harmony with the historical townscape of Khokana and Bungamati.

3) ZONE 3: Urbanization area

This will preserve the townscapes of the 'Historical Settlements' and 'Cultural Landscape' while actively attracting development to accommodate increasing housing demand. It is land separated from the main road for which a infrastructure has not yet been installed, therefore it is necessary to develop it including roads, water and sewer services.

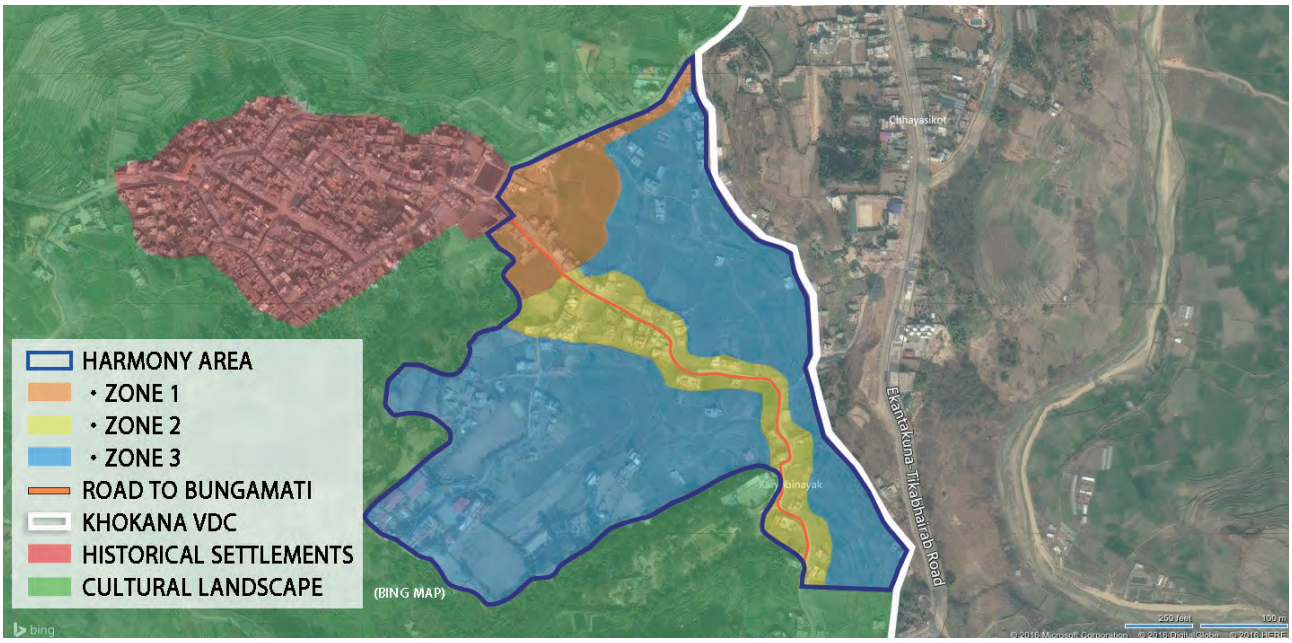


Fig. 5-1-6 The boundary of Harmony area and its three zones (Modified Bing map by author)

(5) Tourism Development Plan

1. Basic idea of the tourism development plan

The 'Historical Settlements' seem to have been earmarked to become one of the main tourist attractions of Khokana in the future, through the improvement of its traditional townscape by the preservation plan outlined above. Along with this preservation plan, the effective development of sightseeing spots of the whole village would maximally enhance the potential for tourism.

2. Tourism development plan

1) Layout of the car parks outside of historical settlements

Inside 'Historical Settlements', especially in Zone 1, motor vehicle traffic should be excluded as much as possible to create pedestrians spaces through which visitors can stroll along the sightseeing routes enjoying the village scape. A circulation plan should be developed in which the car parks for sightseeing buses and tourists' private cars are located in the 'Harmony area' so that visitors can walk into the historical centre after parking their cars. This plan should carefully considered to ensure that it does not negatively influence the historic townscape inside the 'Historical Settlements': for example, the concentration of hotels for tourists should be located near the parking area.

2) Establishment of the sightseeing route for pedestrians

The sightseeing route should be established to enable visitors to both enjoy and learn about the historical townscape and the cultural background of Khokana while walking. The route should effectively show the attractiveness of Khokana, mainly inside ZONE 1. First, they start from the car park inside the 'Harmony area' and visit the conservation centre outlined below, before visiting the mustard oil factory. A tourist map illustrating the sightseeing route should be distributed at the information centre or other convenient spots, so that visitors can walk around easily following this route and then take this map home as a souvenir.

3) Installation of the guide signboards and the signs

The guide signboards corresponding to the sightseeing route or signs for the design of the preservation area should be installed in the appropriate format, structure, colour, etc., harmonising with the traditional townscape.

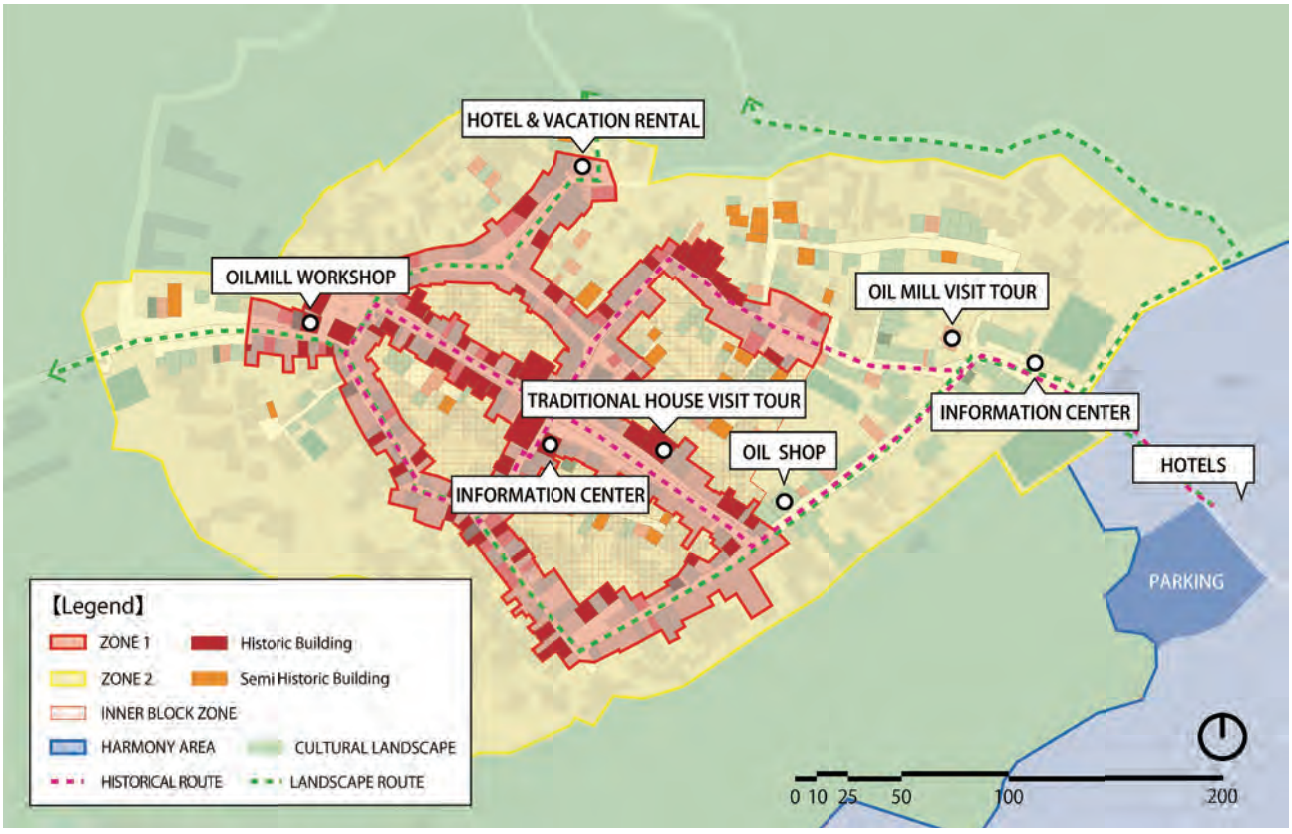


Fig. 5-1-7 Tourism office and tourist route

4) Strategic townscape improvement

Electric poles and overhead wires should be installed without spoiling the townscape. The pavement of the streets should be appropriate for the preservation district. Also, the drainage and its improvement system should be established.

5) Creation of the sightseeing spots making use of public facilities

Public facilities dotted inside the 'Historical Settlements' should be used as sightseeing spots. For example, the ex VDC office of Khokana situated in the centre of the 'Historical Settlements' should be transformed into the Conservation centre for the townscape where visitors can also learn about the historical settlement landscape. The youth centre situated at the east entrance should also transformed into the information centre, providing tourist information and guidance. Visitor tours and workshops should be organised in the mustard oil factories, with shops dotted inside the village to maximally enhance their potential for tourism. Traditional houses should be transformed into accommodation or visiting spots to establish them as reception footholds for tourists or to provide traditional culture.

Fig. 5-1-8 Current view of the area around the bus park

Fig. 5-1-9 View from the historical route

Fig. 5-1-10 Poles disturving the townscape

Fig. 5-1-11 Mustard oil mill

Fig. 5-1-12 The traditional building open to the public

5.2. Guideline for Conservation of Traditional Townscape

(1) Outline of the Proposal

1. Goal of design guideline creation

Having a stacking pattern where brick masonry joints are visible has been brought up as an important characteristic of houses made with traditional construction methods. Having construction elements with minute details like carved wood and latticed windows has also been brought up. Both are handmade, individual elements of a facade and it can be thought that the slight differences the elements have born of their handmade nature envelops the townscape. The different elements layering to create the overall scenery is an important point in the preservation of Khokana village's historical townscape.

With the imminent rapid progression of reinforced concrete reconstruction, there is a solid sense even on-site that there is a need for the establishment of a set of guidelines focused on preserving the townscape. From the necessity of a guide in construction that uses reinforced concrete, we surveyed both traditional houses and pre-disaster houses made with reinforced concrete, ascertained room arrangement and way of life, investigated different elements like floor height, foundation, stairways, windows, colors and materials and performed an analysis of façade design typology. With the results of those surveys as a basis, we drew up a proposed guideline working with people related to Khokana.

2. Consolidation of the legal basis related to historical village preservation

We confirmed the regulations under the Department of Urban Developments jurisdiction, clarified the relationship of the following 3 items and acquired the documents.

① "Basic Construction By-laws for Settlement Development, Urban Planning and Building Construction, 2015 (2072 BS)"

② " First Amendment 2017 (2073 BS) of Basic Construction By-laws for Settlement Development, Urban Planning and Building Construction, 2015 (2072 BS)"

③ Draft of guideline for conservation of historic townscape in Khokana prepared by Khokana ward office

Basic Construction By-laws for Settlement Development, Urban Planning and Building Construction, 2015 (2072 BS) (①) was established in 2015, but through its Amendment 2017 (②) we understood that preservation of historic villages was included in the scope. The 13 rules in the draft of guideline in Khokana (③) have been extracted from these construction regulations (②).

To draw up design guidelines with a legal basis in Nepal, we translated these conditions into English, and attempted to accurately ascertain the content of each line.

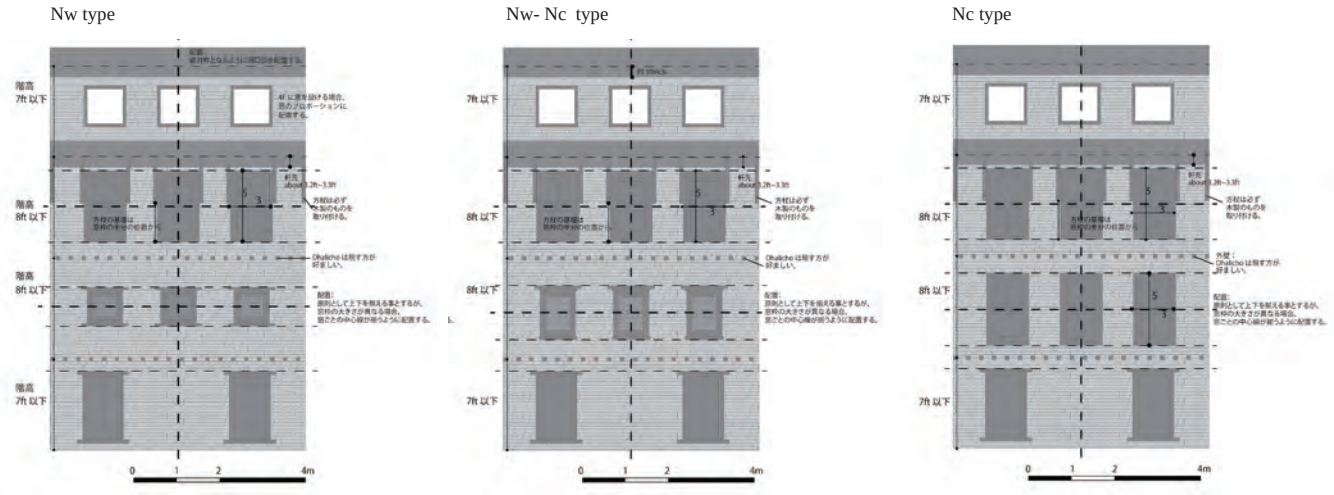


Fig. 5-2-1 Three type of guidelines for new construction, repair and rehabilitation

(2) Basic Policy for Design Guidelines

We have listed points below that we think should be observed overall when looking at things from the viewpoint of townscape scenery preservation.

- House frontage in same position as neighboring houses.
- Wall surfaces in the same position as neighboring houses.
- Axial symmetry maintained in facade.
- Braces attached to 3rd floor portions.
- Corresponding to braces, 3rd floor portion has pitched roof.

Suggestions regarding these guidelines are mainly aimed at newly reconstructed buildings where the historical townscape was maintained. Regarding buildings that have been partially destroyed or suffered damage on only a portion, we aim to show reconstruction policies that make use of existing features while referencing the guidelines. We would like the next problem we tackle to be making suggestions towards guidelines suitable for changes in facades that accompany residential land subdivision brought through inheritance.

We suggest the following 3 patterns, with a basis in the typology that was clarified through surveys, in the event of new reconstructions of traditional houses in Khokana village or in construction to repair a damaged portion, with re-utilization of existing materials like window frames that residents already possess as a prerequisite (Fig.5-2-1).

(3) Design Guidelines for houses newly constructed with reinforced concrete

1. Overview

Splitting into general types, type C, reinforced cement concrete construction with a simple morphology, will be used as the base to set the course of this guideline. In short, what will be recommended is that the outer wall is comprised entirely of brick, masonry joints will not be hidden and that paint will be kept to the absolute minimum or will be used in accordance with the scope of the color guidelines.

2. Items forbidden under by-law

As the following items are already forbidden under by-law with regard to reinforced cement concrete construction, suggestions even in this guideline will be made from the position that they should be protected as a standard.

- Maximum Height: 35 feet, including foundation
- Foundation: Within 450mm - 600mm
- Openings: Shutters forbidden
- Balcony : Forbidden
- Pillar Concealment: Pillars in facades will be hidden behind one layer of brick

3. Contents of Design Guidelines for newly constructed houses

1) Construction method

① Setbacks for number of floors and the top floor

The height limit through by-laws is set at under 35 feet, including the foundation and terrace. We suggest a frame that allows for the 4th floor to be set back, even in 3 floor houses, as a design for the sake of the creation of a townscape scenery in harmony with traditional construction methods. Similar to traditional lifestyles, the plan has the 1st floor used as storage or as a shop, 2nd and 3rd floors as living rooms and the 4th floor as a kitchen.

② Ceiling height

Fundamentally 8 - 9 feet per floor, with respective adjustments made to keep within absolute height. It will be even better if lines can be matched as much as possible with buildings on the side.

③ Depth / Staircases

While a trend to place staircases in the back can be seen, consideration is needed to ensure that they do not expand into the courtyard too much.

④ Foundation

Will fundamentally follow by-laws. However, as it is better to avoid construction where the foundation extend over the property line, we suggest the adoption of special regulations for foundation height using the relationship with the front road based on the following general standard sizes in Nepal.

maximum number of steps =60 / 15.25 = 3.93 ≒ 4 steps

4 steps: (protrusion into front road) ＝ 30.5 x 4 ＝ 122cm

3 steps: (protrusion into front road) ＝ 30.5 x 3 ＝ 91.5cm

2 steps: (protrusion into front road) ＝ 30.5 x 2 ＝ 61cm

Based on that, when the distance from the wall surface of the house till the front road is less than 122cm, it is recommended that special regulations be required (to ensure the property line is not exceeded), that distance to the front road be matched and that more severe height restrictions be adopted. However, in that case, it is necessary to give more detailed consideration to the environmental hygienic functions that foundations have, like drainage.

1. Height

The total height should be less than 31 feet (including roof shall) and total floor height should be 3 or 4 stories.

The maximum floor height shall be 8ft (However, recommendation is 7ft on ground floor and top floor.)

A floor thickness is 4" - 6" guided by general practice.

The maximum Ceiling height shall be 7ft 6inch.

2. The location of wall and eaves

the location of wall

Basically the location of facade wall and eaves need to keep original position.

In case of a new construction, it needs to harmonize with existing traditional house.

3. Roofing

Gabled roof is recmmended and its eaves shall be parallel to front road. Eaves shall be set at the height of second floor on the facade.

Wooden roof trusses, rafters and traditional roof tiles are recommended for roof materials.

The recommended eaves protrude is 3.2ft~3.3ft however shall be followed with the neighbours.

Slope angle shall be 15° ~ 23°.

4. Opening

Basically window size shall follow the traditional size depends on its architectural style(Malla, Rana). Reuse of existing wooden frame is recommended. Number of openings will be determined depends on your lifestyle and width of the house. Openings shall be arranged to keep the facade symmetry. The height of lintel of openings on same floor shall be in same level.

5. Facade

Baked brick is recommended for facade material. No cement plaster. Wood must be used for reinforcement band. Simple carving shall be allowed on it.

6. Brace

Location of brace shall be determined depends on the position, size, and number of opening on second floor. In case of Ga-jya window, four struts shall be set. No carving or simple carving is recommended on brace. The height of base of brace shall be at the middle of window height. The wooden base is recommended.

7. Detail

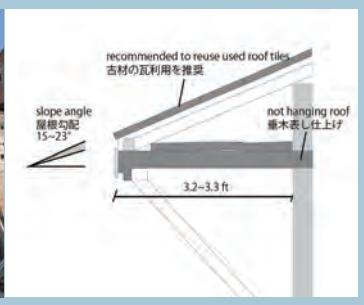
Basically exisiting window and door frames shall be reused. New window shall be followed with the style of facade. Wooden frame is recommended, and sash window shall beset behind the wooden frame not to be visible from outside.

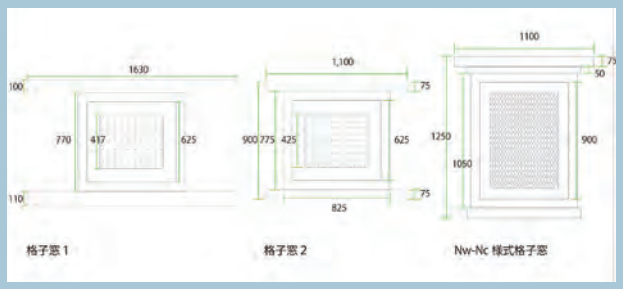
Door frame with sill and lintel is prefarable, however the style shall be determined depends on the usage of ground floor.

Cournices shall be allowed only on the Nc Type facade. Simple design is recommended.

8. Finishing

Basically baked brick is recommended for outer wall finishing (small factory type brick is prefarable). Painting, Cement, or Plaster shall not be allowed on main facade.





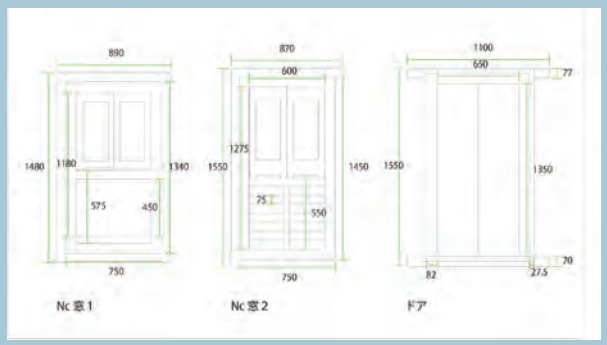


Fig. 5-2-2 Contents for desirble repair and rehabilitation work

2) Facade- Construction elements

① Brick / Pillar concealment

Using a layer of brick to conceal slab or pillars is already set in the by-laws. Additionally, especially for bricks used in the facade, it is recommended the re-utilization of existing bricks. This is because reconstruction is possible at a lower price than using new bricks and because the color scheme of old bricks made before they were mass-produced in factories can be utilized. Additionally, when new bricks are being used, it is recommended that the highest-quality Dachhi Appa bricks not be used and that bricks not treated with oil be used in the case of exposed brick.

② Masonry joints

We're adopting a policy where the austere texture of the masonry joints are presented by not utilizing techniques to hide the masonry joints like in type A, similar to the bricks. Additionally, mud mortar coloration would be preferred in that instance, but when normal mortar is used for strength, a mortar without a unique, strong color should be used.

③ Windows / Openings

Windows will fundamentally use wood as their material and aluminum sash will be forbidden. it is recommended that strong 2-layer windows are used with the wooden portion out in front and the glass set in the back. Guidance for size will be matched to the proportions of traditional neo classical type houses(a 5:3 ratio). Even in the event that there is no option but to choose modern type windows, windows that have a design implemented like lattice are preferable to a single pane of glass.

④ Cornice

It would be good to refrain from using cornice extending from the mid-point of a window or overly flashy decoration like carved bricks. In place of that, it is recommended a simple type, sandwiched only between bricks. However, it is preferable that cornice be applied following the scenery we'll be mentioning later as much as possible. It would be good to not use white lines that could be thought of as faux neo classical.

⑤ Balcony / Terrace

Balconies are forbidden due to by-law. As the horizontal line elements of outer walls will be reduced by the lack of balconies, it's preferable that a simple cornice that isn't too gaudy by used. Additionally, in the event that parapets or handrails are established on a terrace, there is a need to give consideration to matching that color scheme with the village's scenery. Water tanks will be placed

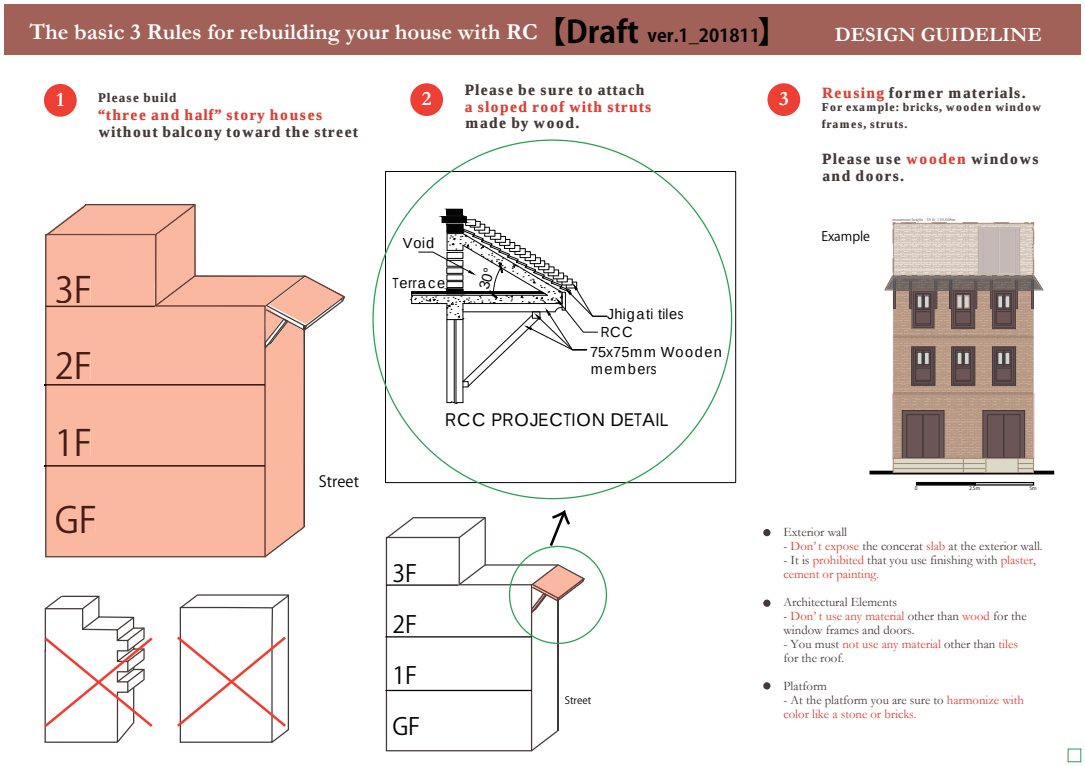


Fig. 5-2-3 Draft of guidelines for new construction, in Khokana

in an area where they cannot be seen from the front road as much as possible. (Another discussion is required for safety related to water tanks.)

⑥ Eaves

It is recommended that eaves are attached to the outer wall on the top floor (second floor). The construction method mimics a traditional roof, a tiled roof utilizing rafters as a gabled roof with a horizontal wooden frame. The proportions of the windows and eaves will be fundamentally be matched with traditionally constructed houses and its desirable that braces come out of the windows at the mid-point in height. Additionally, braces will be simple, without engravings. The height of the eaves themselves will differ from that of the traditional houses, but regarding the relationship between the eaves and the window, the slope of the eaves and the protrusion of the eaves, they will be made in a style that mimics traditional methods. If the slope and protrusion are matched with traditional construction methods, eaves that are higher than the ceiling of the 3rd floor will be required, so the height of parapets on terraces should be adjusted and the eaves should be lowered from there.

⑦ Related to outer walls

When only the top floor has been setback, the outer wall of the top floor should be made to the same specification as the front wall. In particular, it can be thought that some sort of consideration with regard to scenery is required not just for the facade, as slab and pillars can be seen exposed when viewed from the side.

3) Facade - Color elements

Color elements will use a system with specification where color is taken mainly from the material that is utilized. Additionally, guidelines focused on standards for colors used when walls are being reinforced or for wood material, that have a basis in the result of the coloration survey.

① Predominant wall colors

Materials recommended for use

Re-used brick/ Burned brick/ Exposed brick (Chinese)

Materials not recommended for use

Oily exposed bricks (Dacchi Appa)/ Finishing with paint, mortar, or plaster

Observations of scope of color based on survey

The color of brick has a relatively high luminosity of the R type, but the saturation under 6 suppresses it. Bricks lose saturation the older they get, so there is a need to keep saturation low through things like re-using bricks. The mixing of YR type brown bricks with the R type that had a slight redness, along with re-used bricks that have an orange color, is said to be fitting of Khokana, so a color scheme using a scattered pattern would be better.

② Color of openings

The wood is recommended for material of opening frames. When painting openings, we think that a guideline setting the color distribution to match the wood material is suitable. YR types with a low saturation, or R types with a medium luminosity and low saturation are suitable. Thus, in painting wood, a color with a luminosity slightly lower than complete black is desirable. Saturation should have an upper limit set from 6 to 8. A detailed investigation into paint materials is required as we were not able to conduct one in this survey.

③ Partial usage of blue / white colors

These 2 colors are popular in recent years as accent colors, and it is recommended that the usage of white in particular will only be allowed within the scope of the original neo classical style and refraining from the partial use of these colors from here on.

(3) Suggestions for block guidelines

Using a survey of block guidelines as the basis, we will propose an example of a guideline that could be established for blocks in Khokana village.

Taking a look at the overall frame in the long-term, courtyards (Chuka) with appropriate size and function within a block that allow for access to things like through passages will be proactively implemented. This is why, rather than planning the courtyard spaces themselves, guidelines for minimum courtyard measurements will be set and applied in the continuing reconstruction, encouraging the formation of shared courtyards (Chuka) among the neighbourhood.

1. Preservation of existing through passages / New construction

When reconstructing a building, preserve the space of the existing through passage. Additionally, when a new courtyard (Chuka) can be made in a block, the house facing the road will cooperate and construct a new through passage allowing for access.

2. Establishment of a minimum construction space within a block

When reconstructing buildings that neighbor existing courtyard spaces (Chuka), reconstruction that is harmonious with the

neighbourhood will be performed by fulfilling the following conditions.

Direction of depth

・When constructing a building that faces the road, the depth of the building will be 6 - 8 meters.

・When constructing a building parallel to the road behind a road-facing building, it will be constructed 16 meters behind the road.

・Through this, the distance between walls for buildings facing the road and those not facing the road will be over 10(8) meters.

Direction of width

・The distance between walls for buildings standing perpendicular to the road will be over 4 meters.

・In the event of a parallel type courtyard, where buildings standing perpendicular to the road do not provide frontage, the width (space between wall surfaces) of the courtyard will be over that of 2 houses

3. Others

・When the above measurements are not possible, adjustments will be made so that the house with the largest courtyard (Chuka) faces the edge of the block.

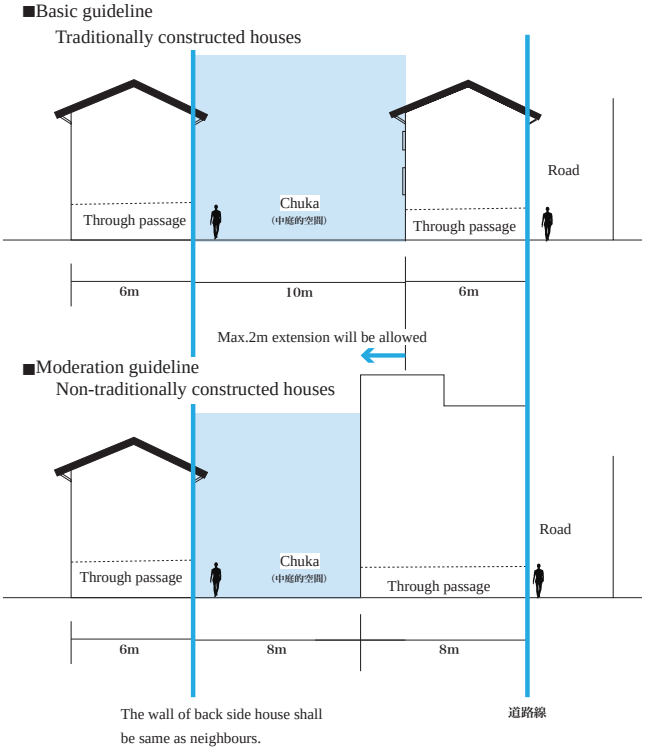


Fig. 5-2-4 Conservation methods for size of courtyard in Khokana

・The direction of frontage for houses in a block will face towards one of the courtyards (Chuka).

→ The pattern of a Chuka will be set as either a parallel type or an enclosed type.

→ Residents will have the right to share the Chuka their frontage is facing.

・The measurements shown above will need to be adjusted on a per-block basis.

As this investigation was limited to the analysis of tangible measurements, it would be difficult to implement these guidelines as they are and further investigation is required both culturally and into other problems. From here on, there is a need to investigate various spatial conditions, like overlap between sunshine and direction, pavement, the problem of sunlight and the height of reinforced concrete construction, the relationship to drainage channels, courtyard proportions (the possibility of the introduction of a minimum measurement in the form of a combined width and depth) and overlap with the construction area (toilet location). At the same time, there is a need to investigate various social conditions like the problem of property lines (how to exchange or share sites), the function served by courtyards in Nepal culture, the evaluation of private courtyards owned by families and ascertaining how to maintain Khokana's identity.

(4) Suggestions for the creation of a townscape (Methods and viewpoints as a building group)

It is also going to be necessary to make rules for the village as a whole that match with the guidelines of each building to ensure the creation of satisfactory scenery. Points that should be investigated are listed below.

1. Building line

Cases where the property line is not being protected can be seen here and there in Khokana. As unifying wall surfaces and roof slopes will tie in to improving the scenery, there is a need to unify the building line and avoid setbacks and foundation protrusions along the front road.

2. Unification of foundations along sloping roads

The sense of unity along sloping roads falls apart easily through things like differing rates of foundation replacement and

construction methods. Long-term, it can be thought that it would be good to unify under one of the 2 styles listed below, however, consideration is also required for things like drainage as foundations have different uses.

3. Discussions on parallel lines

The horizontal line along things like eaves and walls is raised when talking about unifying with surrounding buildings. It can be thought that deciding on consistent rules to unify absolute height, height of openings on each floor and eaves will further contribute to a symmetrical townscape.

4. Working with environmental factors that have given consideration to townscape

The phenomenon of facility type items like water pipes, water tanks and lamps protruding from the façade can be confirmed at individual houses with reinforced concrete construction, but it can be thought that this problem will become more evident along with changes in lifestyle. A plan is needed to solve problems that cannot be handled on an individual level, to control environmental factors in the town, like utility poles and road pavement, as elements that make up the townscape.

5. Color space

For example, a handrail near a pond can be determined that its color scheme is not suitable to the color space of Khokana's scenery when viewed in contrast with the adoption of a color scheme that is centered on red and brown colors at temples and public facilities. There is a need to give consideration to the color scheme used in these sort of environmental factors and public spaces to protect the scenery of the townscape through matching with the consideration given to individual houses.

6. Conclusion

6. Conclusion

6.1. Conclusion

It has been almost five years since the earthquake occurred. Many damaged cultural heritages including world heritage sites are still undergoing rehabilitation. In historic settlements like Khokana, traditional houses have been rebuilt in the RC structure, which has changed the townscapes a great deal.

The suggestions for each issue on the conservation of historic settlements are proposed below:

(1) Problems clarified through the investigation of disaster circumstances and a future perspective

Two problems were identified concerning the damaged houses built with the traditional construction method and those built with non-traditional methods:

1. Problems concerning the damaged houses built with traditional construction methods.

1) Restoration and reinforcement method for partially damaged traditional houses

Regarding the partially damaged houses, the specific measures, such as examining the possibility of the restoration and reinforcement work making use of residual parts, have not yet been determined. Establishment of the restoration and reinforcement methods is an urgent issue from the viewpoint of townscape conservation. Technical support and the further practical examinations recommended based on the results of the microtremor measurements by the structure team are both needed in the future.

2) Rebuilding techniques for the traditional houses.

Regarding private houses, the incentive for rebuilding with the traditional construction method, namely financial support, should be established. The conservation of the settlements in the future therefore depends on the inhabitants' intention to fund the associated costs. Certain rules, including agreements among the inhabitants, mainly concerning the Khokana Reconstruction and Rehabilitation Committee or the structure of any financial support, should be established.

2. Problem concerning the houses built with non-traditional construction method

The damage suffered by houses built with non-traditional construction methods was relatively slight. However, the number of houses built with non-traditional construction methods was approximately 40% of the total number of houses we investigated just after the earthquake, and those houses have obstructed the historical townscape. It is obvious that the number of houses built using non-traditional construction methods has increased through the rehabilitation process.

"Basic Construction Guideline for Settlement Development, Urban Planning and Building Construction, 2015 (2072 BS)" was enacted in September 2015, just after the earthquake. After its amendment in 2017, the conservation of historic settlements was included its scope and regulations for new constructions were established. However, there are future issues such as needs for management guidelines, to introduce the incentive system, and further improvement of regulation items which are not suitable for the current condition of settlements.

Along with guideline on the number of floors or the height of each floor being appropriate to the historical townscape, guidelines on the detailed facade design, such as appropriate materials, should be developed.

(2) Systemic problems

To establish a system for townscape control, it is necessary to unify the methods of cultural property protection with those of urban planning. However, as both of these are not yet fully developed in Nepal, there are many problems to be solved.

1. Problems concerning the administration of cultural heritage, such as evaluation or definition

In the rehabilitation guidelines being developed after the earthquake by the Department of Archaeology, 'Historical Settlements' was used for the first time. It is necessary, however, to protect the houses built with traditional construction methods, to

restore the existing traditional houses, and to establish the financial incentive to rebuild using the traditional method.

2. Problems concerning the administration of urban planning

The residential land development area along the arterial road, 'Ekantakuna-Tikabhairab Road', has reached right before the Khokana Settlements. It is necessary to establish the legal grounds to conserve Khokana Village as cultural property and to reflect this on the land use plan to be developed as an integrated measure. Recent concerns include the chaotic expansion of the region, such as the development of the area surrounding the village, along with perpetuating expanded farm roads leading to temporary houses. Regarding the building restriction for houses built using non-traditional construction methods, it is necessary to cooperate with the administrative body responsible for building control.

3. Conservation plan

Considering the results of these investigations, our conservation plan is proposed in Chapter 5. This proposition of the framework to preserve the traditional settlements is one of the key tangible contributions of this report, but the habitants' actual responses should be considered. When the inhabitants' opinions are gathered during the symposium of this investigation which is to be held in the future, the plan should be improved and further materialised. Furthermore, the ideal is give unify cultural properties protection administration and the urban planning administration.

(3) Future issues of the Historical Settlements as the inscribed site on the tentative World Cultural Heritage list

The strategy of extending the World Heritage site of the Kathmandu Valley needs to be formulated. The four sites registered in the tentative list were the residential areas of the people who were active around the royal palaces inside the Kathmandu Valley, such as the base village of the former trade roads and the village with Medieval monuments; they are intended to be added in to the World Heritage Site list as properties which have historical relations with the Kathmandu Valley.

As already detailed above, Rajkulo, built as the water supply system of the Kathmandu Valley, for example, supplies water to watering places and ponds of the three royal palaces of Kathmandu, and it has also functioned as the irrigation canal circulating water throughout the Kathmandu Valley. There are no records of who built Rajkulo, and with few existing sources following rapid urbanization, its whole story has not yet been revealed. However, it is easy to imagine that this system contributed to the settlements around the royal palaces. It is necessary to investigate the lives of inhabitants throughout the whole valley at that time in order to explain the universal value of this water system.

Moreover, the demarcation of the boundary of the property and its buffer zone needs to be examined. Integrated agreements with the urban planning administration are needed, as detailed earlier.

(4) Project Proposals

The following four projects are proposed.

1. Pilot project of the structural reinforcement for the damaged houses built in traditional construction methods

Launch the pilot project on structural reinforcement; if realising the reinforcement of private houses is difficult, aim, for example, to establish the restoration reinforcement technique for the partially destroyed mustard oil factories built using the traditional construction method (common ownership buildings) inside the residential area,.

2. Mustard oil factories base arrangement project

This project is for tourist development, for example by transforming and arranging closed factories into exhibition spaces to be visited by tourists.

3. Water spaces improvement project

The culturally important water spaces should be improved with the support of Japan International Cooperation Agency (JICA) as the portent project of earthquake disaster rehabilitation. The water supply system in the valley seems to have high technical and cultural values, in addition to its strong relation with intangible culture. It is desirable, therefore, that this old wisdom should be re-evaluated and renovated.

4. Re-evaluation and Rehabilitation project of Rajkulo

Deep understanding and rehabilitation of Rajkulo should be re-evaluated, not only because as one of the measures to resolve

the chronic water shortage in the urban area of Kathmandu, but also because it is one of the important systems underpinning the prosperity, life, and culture of the Kathmandu Valley.

Lastly, as seen in the redevelopment of houses in Khokana, the November 2016 survey conveyed the partial repair of damaged houses. However, after the survey in June 2017, rebuilding with RC structures increased. In December 2017, damaged houses were removed. In August 2018, rebuilding with RC structures was accelerated. In March 2019, the number of houses rebuilt in the RC structure reached 99. According to the survey, there was a time limit for establishing the support system for the rehabilitation of traditional houses (private properties); that time limit was one or one and half years after the earthquake.

It is necessary to seek desirable conservation and rehabilitation methods for historic settlements in the area, which are at continued risk of natural disasters; we must implement the lessons learned from Khokana.