2015 Project for International Contribution to Cultural Heritage Protection

Project for Investigation of Damage Situation of Cultural Heritage in Nepal

Project Report

March 2016

National Research Institute for Cultural Properties, Tokyo

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Frontispiece 1: Aganchen Temple, first storey, east side, 02 Dec. 2015

Frontispiece 2: Hanumandhoka, main gate façade, 02 Dec. 2015
(Main gate on the right bottom, the three-storey building with white walls is the west wing of Mohan Chok)

Frontispiece 3: Hanumandhoka Durbar Square , 17 Sep. 2015

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Frontispiece 5: Townscape of Khokana village, 20 Sep. 2015

Frontispiece 6: Terrace rice fields in the periphery of Khokana village, 22 Sep. 2015

Acknowledgements

This report is the result of an investigation of cultural heritage damage caused by the Gorkha Earthquake on 25 April 2015. The project was commissioned by the Agency for Cultural Affairs and conducted by the National Research Institute for Cultural Properties, Tokyo (NRICPT).

Like Japan, Nepal experiences frequent earthquakes and has reconstructed and rebuilt their cultural heritage following each disaster. Their cultural heritage is a trace of their history and culture, in which the wisdom of their ancestors and historical cultural values are accumulated. The Nepalese people are undertaking strenuous reconstruction efforts to retain and share cultural heritage values; the people of Japan face similar duties.

In this project, investigations were conducted from comprehensive viewpoints including architectural history, building structure, urban design, conservation and preservation, and intangible cultural heritage by researchers from Nippon Institute of Technology, the University of Tokyo, Kagawa University, Tokyo Metropolitan University, Tohoku Institute of Technology, and NRICPT, as well as outside experts in cultural heritage conservation.

The investigation of damage to historical monuments and historic areas provided not only an understanding of the current situation, but also the necessary advice and guidance for on-site personnel regarding emergency preservation measures for historical monuments spared from total collapse.

We hope the results of this project will encourage the preservation of cultural heritage during reconstruction of the damaged regions in Nepal, and contribute to the further development of cordial relations between Japan and Nepal in the future.

During the project, we worked collaboratively with numerous organizations including Japan's Agency for Cultural Affairs, the Japanese Embassy in Nepal, Nepal's Department of Archaeology (DoA) of the Ministry of Culture, Tourism and Civil Aviation; and the United Nations Educational, Scientific and Cultural Organization (UNESCO) office in Kathmandu. We would like to thank each organization for their cooperation.

Finally, we would like to send our sincere gratitude to Mr Besh Narayan Dahal, Director General of DoA; Ms Nabha Basnyat Thapa, Project Coordinator of UNESCO-Kathmandu Office; Ms Saraswati Singh, Executive Director of Hanumandhoka Durbar Museum Development Committee, and the members of the Khokana Reconstruction and Rehabilitation Committee.

Nobuo Kamei
Director General
National Research Institute for Cultural Properties, Tokyo

Legends

This report presents this project’s investigation and information exchange results from 1 September 2015 to 31 March 2016. This project, titled “Project for Investigation of Damage Situation of Cultural Heritage in Nepal” , was commissioned by Japan’s Agency for Cultural Affairs as a 2015 Cooperation Project for Preservation of Cultural Heritage (Exchange of Experts).

Six types of surveys were conducted during this project related to the following: (1) the extent of cultural heritage damage, (2) traditional techniques of historic buildings, (3) structural analysis, (4) emergency preservation measures, (5) in-depth historic settlement impacts, and (6) intangible cultural heritage impacts. This report provides only summarized results of each survey. Detailed survey information of (3) and (5) was published as individual stand-alone reports.

Contents

1. Outline of the Project

1. Outline of the project

1.1. Aim of the project

This project, titled “Project for the Survey on the Extent of Damage to the Cultural Heritage in Nepal”, was commissioned by Japan’s Agency for Cultural Affairs as a Cooperation Project for Preservation of Cultural Heritage (Exchange of Experts) during fiscal year 2015.

On 25 April 2015, a 7.8 magnitude earthquake with its epicentre in the Gorkha District of central Nepal (hereafter referred to as the ‘Gorkha Earthquake’) caused enormous damage—including landslides and building destruction—in a large area that included the capital city of Kathmandu. Reaching also the neighbouring countries, the loss of human lives was significant and the damage to cultural heritage was severe.

The damage caused by the Gorkha Earthquake directly affected many of the heritage assets included in the World Heritage List, and extended into the historic urban areas including the buffer zones. Soon after the earthquake occurred, the Secretary General of UNESCO made an appeal for international cooperation, and experts and survey teams from several countries, including Japan, visited the disaster-struck areas to survey and report on the extent of damage. The cultural heritage damage was extremely severe, especially regarding the multi-tiered buildings of the Durbar Squares and the temples in the World Heritage Site of Kathmandu Valley. Several important buildings completely collapsed or suffered catastrophic damage. Other historical buildings suffered only minor damage and required comprehensive analysis that included factors such as the typology, state of conservation, and strength of the terrain for each building. Because the clean-up of debris surrounding the ruined buildings advanced rapidly, a system of recordkeeping and a method for proper storage of architectural members were urgently needed with a view towards future repair or reconstruction work. In addition, emergency measures were needed to prevent further damage to the affected buildings.

Given the situation and need for urgent response, this project aimed to (1) provide technical information and support regarding the damaged buildings in Nepal (especially those in Kathmandu City), (2) gather the required information for the future recovery process, and (3) strengthen the specialized response capacity of personnel in charge of cultural heritage in both Nepal and Japan through cooperation with local agencies.

1.2. Duration of the project

The overall duration of the project was seven months, from 1 September 2015 to 31 March 2016. Individual durations of the on-site surveys are detailed later in Section 1.5.

1.3. Target area of the survey

Seven areas that constitute the World Heritage Site of Kathmandu Valley, together with three historical settlements included in the World Heritage Tentative List (currently under consideration for inclusion in the World Heritage List) were selected as possible target areas for the survey. Each site was visited during a scouting mission in September 2015. Based on the results of these visits, and taking into account factors such as 'historical value of the cultural heritage', 'urgency of the survey', 'demands of local organizations' and 'movements of each country regarding international cooperation', Hanumandhoka Durbar Square was selected among the areas in the World Heritage List and Khokana was selected among the areas in the Tentative List (Fig. 1–3). The basis for selection of and the extent of damage in these target areas is detailed in Chapter 2.

In Hanumandhoka Durbar Square, the following buildings were identified for survey:

- Aagan Temple (Aganchen Mandir) in Hanumandhoka's Royal Palace (Hanumandhoka Durbar), Sundari Chok, and the west wing of Mohan Chok were surveyed to determine the extent of damage to these buildings.
- Jagannath Temple, Gopinath Temple (Srikrishna Mahavishunu Temple), and two temples located in Hanumandhoka Durbar Square that are currently involved in a Japan Funds-in-Trust repair project for UNESCO were surveyed to determine the extent of damage to these buildings, including structural damage.
- Shiva Temple was selected to develop a methodology for classifying, storing, and recording salvaged members from collapsed buildings; the members from this temple were relatively easy to identify and separate from those of other nearby collapsed buildings.

Fig.1-1 Location of Nepal and Kathmandu

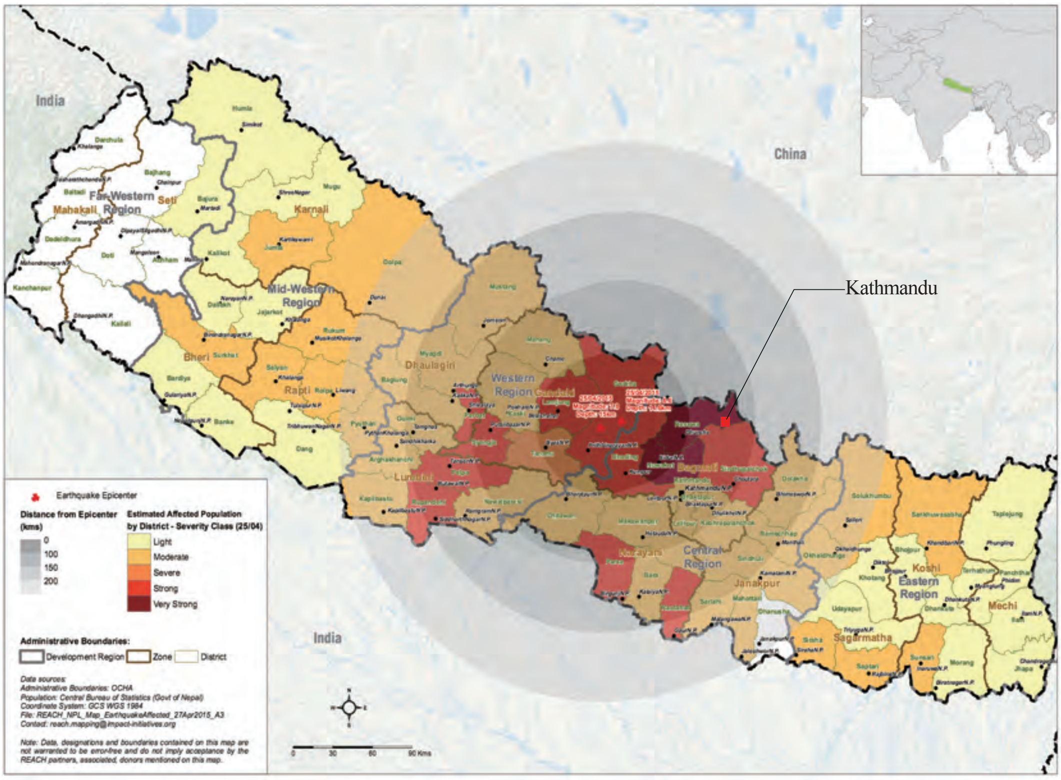


Fig.1-2 Location of the seismic center of the Gorkha earthquake (Map of the extent of the earthquake damage by REACH http://reliefweb.int/map/nepal/nepal-april-2015-earthquake-estimated-affected-areas-25th-april-2015

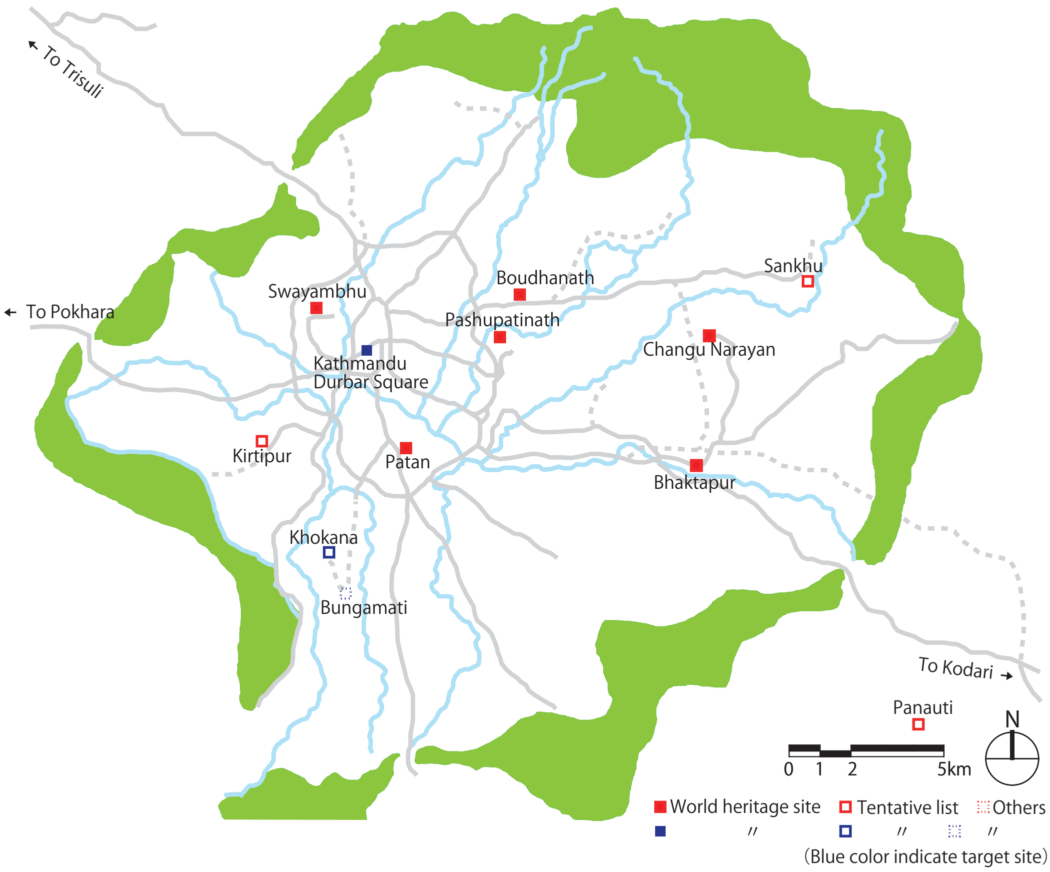
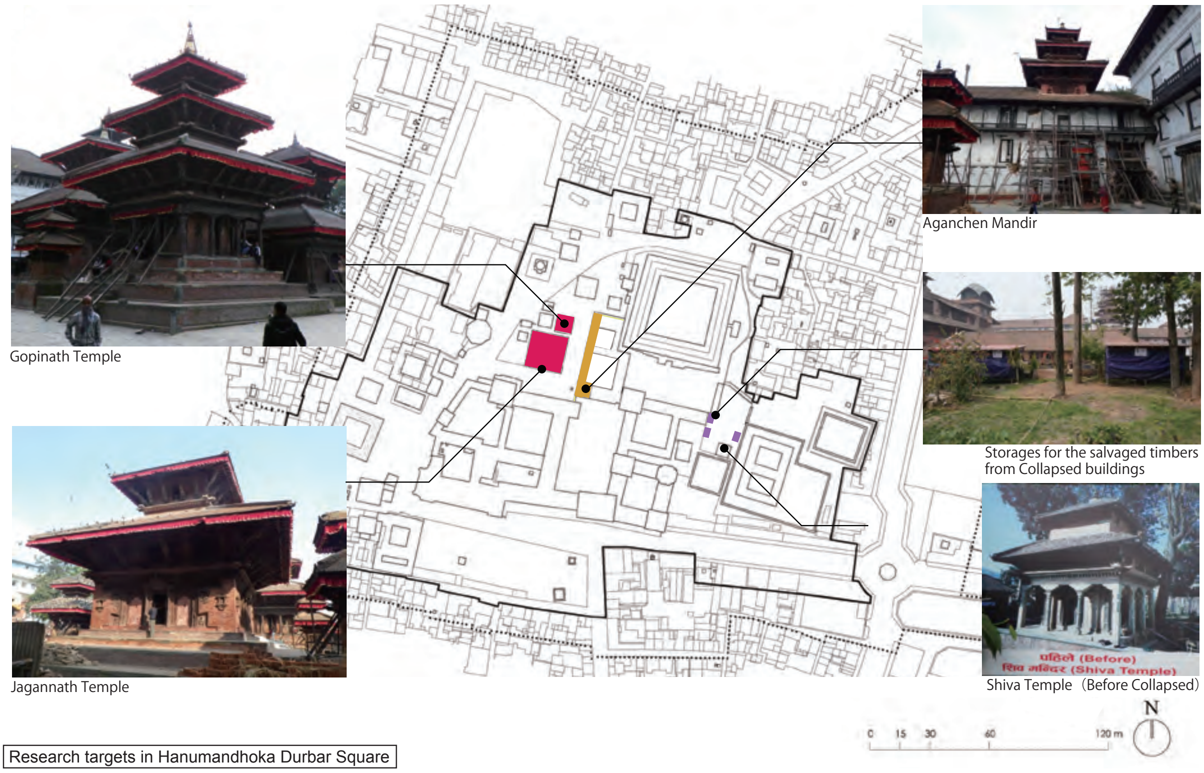


Fig.1-3 Properties of World Heritage Site Kathmandu Valley and historical settlements on the tentative list



Research targets in Hanumandhoka Durbar Square

- Survey on Extent of Damage, 3D and micro-tremor measurement（Jagannath and Gopinath Temple)
- Survey on Extent of Damage, 3D measurement (Outside of Aganchen Temple and west side of Mohan chok)
- Survey on the salvaged timbers from the collapsed building and storaging them（Shiva Temple）

Fig.1-4 Target buildings in Hanumandhoka Durbar Square

1.4. Members of the survey team

The experts that took part in this project are shown in Table 1-1. Select aspects of the project were recommissioned to experts from the University of Tokyo. The Mikio Koshihara Laboratory in the Institute of Industrial Science at the University of Tokyo led the structural analysis of the damaged cultural heritage buildings. The Yukio Nishimura Laboratory in the Research Centre for Advanced Science and Technology at the University of Tokyo led the survey on the use of urban space in damaged historical settlements.

Tab.1-1 Members of the survey team

Working Group	Name	Affiliation	Speciality
Responsible person	Nobuo KAMEI	Director general, National Research Institute of Cultural Property, Tokyo (NRICPT)	Architecture
Supervision	Wataru KAWANOBE	Director of Japan Center for International Cooperation in Conservation, NRICPT	Chemical Analysis
Survey on emergency protection measures	Masahiko TOMODA	Head of Conservation Design Section, NRICPT	Architecuture, Conservation
	Tadatsugu TAI	Senior Conservation Architect, Cultural Property Center of Wakayama Prefecture	Architecuture, Conservation
	Minoru FUKUCHI	Carpenter specializing in traditional shrine and temple buildings	Architecuture, Conservation
Survey on characteristics of historical buildings and areas	Takayuki KUROTSU	Professor, Faculty of Engineering, Nippon Institute of Technology	Architectural History, Conservation
	Shinichi NISHIMOTO	Professor, Faculty of Engineering, Nippon Institute of Technology	Architectural History
	Manabu UEDA	Assistant Professor, Faculty of Engineering, Nippon Institute of Technology	Structural Engineer
	Yukio NISHIMURA	Professor, Research Center for Advanced Science and Technology, The University of Tokyo	Urban Design
	Tomoko MORI	Assistant Professor, Research Center for Advanced Science and Technology, The University of Tokyo	Urban Design
	Takeshi KUROSE	Assistant Professor, Faculty of Engineering, The University of Tokyo	Urban Design
	Yasushi TAKEUCHI	Associate Professor, Faculty of Engineering, Tohoku Institute of Technology	Urban Design
	Hiroki YAMADA	Associate Fellow, Japan Center for International Cooperation in Conservation, NRICPT	Urban Design
	Naoaki FURUKAWA	Visiting Researcher, NRICPT/ Project Assistant Professor, Faculty of Urban Environmental Sciences,Tokyo Metropolitan University	Urban Design
	Kumiko OGUMA	Associate Professor, Research Center for Advanced Science and Technology, The University of Tokyo	Urban Conservation Systems
	Bijaya K. SHRESTHA	Visiting Faculty, Department of Urban design & conservation, Khwopa Engineering College	Urban Design
Structural survey of historical buildings	Mikio KOSHIHARA	Professor, Institute of Industrial Science, The University of Tokyo	Structural Engineer
	Noriko TAKIYAMA	Associate Professor, Faculty of Urban Environmental Sciences, Tokyo Metropolitan University	Structural Engineer
	Mitsuhiro MIYAMOTO	Associate Professor, Faculty of Engineering, Kagawa University	Structural Engineer
	Hiromi SATO	Assistant Professor, Institute of Industrial Science, The University of Tokyo	Structural Engineer
	Masataka KAGESAWA	Assistant Professor, Institute of Industrial Science, The University of Tokyo	Structural Engineer
Survey on intangible heritage	Mitsuru IIJIMA	Director of Department of Intangible Cultural Heritage, NRICPT	Intangible Cultural Heritage
	Hiromichi KUBOTA	Head of Intangible Folk Cultural Properties Section, NRICPT	Folklore
	Tomo ISHIMURA	Senior Researcher, Department of Intangible Cultural Heritage, NRICPT	Archaeology

1.5. Duration of the on-site surveys

The on-site surveys were carried out according to the schedule. The mission duration extended from the departure date from Japan to the arrival date to Japan.

First Mission

Duration of the mission: From 14 September to 23 September 2015.

Outline of the survey:

Seven experts in architecture, urbanism, structural engineering, and intangible heritage were initially sent to Nepal. Meetings were held with agencies concerned with the preservation of historical heritage, including the Department of Archaeology (DoA) of the Ministry of Culture, Tourism and Civil Aviation; the UNESCO-Kathmandu Office and the Hanumandhoka Durbar Museum Development Committee (HDMDC). In addition, participating experts surveyed the former royal palaces of Kathmandu, Patan, and Bhaktapur (included in the World Heritage List) and the suburban settlements of Sankhu, Kirtipur, and Khokana (included in the Tentative List) to identify buildings and areas for the primary survey and determine the survey methodology. The Indra Jatra festival—the most important festival in Kathmandu—was also surveyed.

Participant experts (duration of the mission):

Masahiko Tomoda (from 14 September to 23 September)
Hiroki Yamada (from 14 September to 23 September)
Tomoko Mori (from 14 September to 23 September)
Mitsuhiro Miyamoto (from 15 September to 28 September)
Hiromichi Kubota (from 20 September to 28 September)
Tomo Ishimura (from 20 September to 28 September)
Takayuki Kurotsu (from 7 September to 19 September)
*financed by the project of Nippon Institute of Technology. Joined the mission partially between 15 and 17 September.
Shinichi Nishimoto (from 7 September to 19 September)
*financed by the project of Nippon Institute of Technology. Joined the mission partially between 15 and 17 September.

Assistants:

Sakura Kawata (from 21 November to 8 December)
*financed by the project of the University of Tokyo

Second Mission

Duration of the mission: From 31 October to 5 November 2015.

Outline of the survey:

2 experts in architectural structures were sent to Nepal, they had meetings regarding the testing of materials and carried out a survey on the foundation structure of damaged buildings.

Participant experts (duration of the mission):

Mitsuhiro Miyamoto (from 31 September to 3 November)

Noriko Takiyama (from 31 September to 5 November)

Third Mission

Duration of the mission: From 31 October to 5 November 2015.

Outline of the survey:

In a third mission, 20 experts in architecture, urbanism, structural engineering and intangible heritage were sent to Nepal. They surveyed Kathmandu Durbar Square and Khokana settlement. In Kathmandu, the extent of building damage was recorded and three-dimensional (3D) and micro-tremor measurements were obtained for structural analysis. In addition, a trial classification and storage method was followed and evaluated for salvaged members from collapsed buildings. Lastly, a workshop was held for local employees (with 12 local participants). Comparatively, in Khokana, a multidisciplinary survey on the extent of building damage in the settlement, the nature and extent of structural damage, the historical development of building typologies, the intangible heritage impacts, and the water quality impacts was carried out in coordination with the local community organizations.

Participant experts (duration of the mission):

Masahiko Tomoda (from 21 November to 27 November)

Hiroki Yamada (from 21 November to 8 December)

Tomo Ishimura (from 21 November to 25 November)

Tomoko Mori (from 21 November to 8 December)

Tadatsugu Tai (from 21 November to 30 November)

Takefumi Kurose (from 21 November to 25 November)

Takayuki Kurotsu (from 23 November to 3 December)

Manabu Ueda (from 23 November to 2 December)

Noriko Takiyama (from 26 to 30 November,and from 3 December to 7 December)

Mitsuhiro Miyamoto (from 27 November to 7 December)

Hiromi Sato (from 27 November to 7 December)

Masataka Kagesawa (from 27 November to 1 December)

Mikio Koshihara (from 29 November to 7 December)

Naoaki Furukawa (from 1 December to 8 December)

Kumiko Oguma (from 1 December to 8 December)

Assistants:

Sakura Kawata (from 21 November to 8 December)

Taiga Sunazuka (from 23 November to 8 December)

Haruka Okuhiro (from 27 November to 7 December)

Yoshihiro Morito (from 27 November to 7 December)

Daima Teramura (from 27 November to 7 December)

Fourth Mission

Duration of the mission: From 23 December to 28 December 2015.

Outline of the survey:

In a fourth mission, three structural experts were sent to Kathmandu to conduct meetings with the local DoA and Tribhuvan University regarding the testing of materials.

Participant experts (duration of the mission):

Noriko Takiyama (from 23 December to 28 December)

Mitsuhiro Miyamoto (from 23 December to 28 December)

Mikio Koshihara (from 25 December to 28 December)

Fifth Mission

Duration of the mission: From 7 March to 27 March 2015.

Outline of the survey:

In a fifth and final mission, four architecture experts were sent to Kathmandu to survey production techniques for traditional building materials, assess the cultural value of the subject buildings, and continue classifying salvaged members from collapsed buildings.

Participant experts (duration of the mission):

Takayuki Kurotsu (from 7 March to 19 March)

Masahiko Tomoda (from 16 March to 27 March)

Tadatsugu Tai (from 18 March to 25 March)

Minoru Fukuchi (from 18 March to 27 March)

1.6. Outline of the survey

Six types of surveys were conducted during this project related to the following: (1) the extent of cultural heritage damage, (2) traditional techniques of historical buildings, (3) structural analysis of damaged buildings, (4) emergency preservation measures, (5) in-depth historic settlement impacts, and (6) intangible cultural heritage impacts.

1.6.1. Extent of cultural heritage damage survey

Nepal’s cultural heritage was heavily damaged as a result of the Gorkha Earthquake. To provide appropriate technical support to the preservation sector of Nepal’s government in the interest of international cooperation, it was first necessary to assess the extent of cultural heritage damage.

This survey was largely carried out during the initial mission in September 2015. A general survey was conducted to determine the extent of the damage to Kathmandu Royal Palace, Patan Royal Palace, Bhaktapur, Changu Narayan, Boudhanath, and Swayambhu in the World Heritage Site of Kathmandu Valley, as well as Nuwakot, Kirtipur, and Sankhu in the World Heritage Tentative List. Information was also gathered through meetings conducted with members of the DoA, the UNESCO-Kathmandu Office, Hanumandhoka Durbar MDC, United Nations (UN)-Habitat programme, and the Khokana and Bungamati Reconstruction and Rehabilitation Committees. Coordination and information sharing also occurred with the Japanese Embassy in Nepal, the Japan International Cooperation Agency (JICA), and the Japan Consortium for International Cooperation in Cultural Heritage. Two experts who participated in this project—Kurotsu and Nishimoto—also participated in a post-earthquake survey led by JICA to determine the extent of damage. The knowledge gained in the JICA survey was reflected in this project. The results of this project's survey are presented in Chapter 2.

1.6.2. Traditional techniques of historic buildings

While some studies have considered the architectural styles of Nepal's historic buildings, little research exists on traditional building techniques. The conservation and repair of Nepal's historic buildings has largely been entrusted to the knowledge and experience of craftspeople. Following an earthquake event, when repair and structural reinforcement are imminent, it is desirable to employ methodologies and techniques that allow for maximum retention of cultural value and authenticity. Thus, a survey was conducted to describe traditional building techniques and their features that would support conservation efforts. Differences related to building typology, scale, and age were taken into account.

This survey was conducted in November 2015 and March 2016 for Aganchen Mandir (Aaganchen Temple) at Hanumandhoka and in the surrounding historic buildings. Experts from the Nippon Institute of Technology conducted a separate survey in September 2015 for the Bhairabi Temple in Nuwakot to gather information for future repair work. The knowledge gained in this prior survey for the Bhairabi Temple was reflected in this survey.

Regarding traditional techniques, building material (e.g. bricks and tiles) production and carpentry techniques are important in building conservation; how these techniques have been passed down generationally and how materials have evolved in past repair work must be surveyed. The survey conducted during this fiscal year focused on bricks.

A summary of these results is presented in Chapter 3. A detailed report with drawings, titled "Survey on the traditional techniques of historic buildings", was prepared separately.

1.6.3. Structural analysis of damaged buildings

Through the surveys carried out so far, it is possible to have an understanding of the extent of damage. In this survey, using these results as a reference, an initial assessment of the weak points during earthquakes was made through a structural analysis and observation of the timber and brick mixed structure historic buildings in Nepal. Among the historic buildings, Jagannath Temple and Gopinath Temple, which are the target of a Japan Funds-in-Trust for UNESCO project, were selected as case studies, and a detailed survey including 3D measurements and microtremor measurement was carried out. Measured drawings of the target buildings were prepared, the damaged parts and level of damage of brick and timber (the main structural materials) was surveyed and recorded, and preparations were made for a sample testing of the building materials.

The details of these surveys, including the obtained data, are included in a separated report of this project, titled "Structural Survey of Historic Buildings". A summary of this report is included in Chapter 4.

1.6.4. Emergency preservation measures survey

Although the number of historic buildings affected by the Gorkha Earthquake was extremely large, the clean-up of debris advanced rapidly. It was important to adequately survey and record architectural members (especially timber members) as indictors of the building structure when no other detailed records existed and to salvage any reusable members for future recovery work.

Buildings that have suffered damage but are still standing require more urgent measures, such as shoring and covering, to prevent further damage caused by rain and aftershocks. If these measures are inadequate, the cultural value of these buildings is at risk. Therefore, a survey on emergency preservation measures was conducted during the initial mission in September 2015. Subsequently, during the November 2015 and March 2016 missions, a classification, recordkeeping, and storage methodology for salvaged members was tested and evaluated using the Shiva Temple—where salvaged members are relatively well preserved—as a case study,. In November 2015, a workshop on the classification, recordkeeping, and storage methodology was conducted with local experts from the DoA, HDMDC, and UNESCO to transfer this technical knowledge. The results of this survey are presented in Chapter 5.

1.6.5. Historic settlement survey

The historic settlements in Kathmandu Valley also suffered heavy damage as a result of the Gorkha Earthquake. During the first mission in September 2015, the extent of damage was surveyed in the settlements of Kirtipur, Sankhu, and Khokana (included in the World Heritage Tentative List). Khokana was selected for comprehensive, in-depth survey. An information exchange session was conducted with Takeuchi, an Associate Professor at the Tohoku Institute of Technology, who had previous survey experience in Khokana. In addition, this survey effort was coordinated with a local community organization—the Khokana Reconstruction and Rehabilitation Committee.

This comprehensive, in-depth survey considered the settlement space from a cultural perspective, the extent of cultural heritage damage, the historical development of urban typologies, structural impacts including micro-tremor measurements, intangible heritage impacts, and water quality. The survey was conducted in Khokana between 21 November 2015 and 7 December 2015.

A summary of these results is included in Chapter 6. A detailed report, titled ‘Survey on the Historic Settlement, Khokana’, was prepared separately.

1.6.6. Intangible cultural heritage survey

Nepal has a multi-ethnic population with a rich intangible cultural heritage that brings together ethnic groups, castes, and local communities. In Nepal, tangible and intangible heritage conjoin to form a single entity; it is not possible to understand one without understanding the other. For the subjects of this survey—the Hanumandhoka religious buildings and the Khokana settlement—intangible cultural heritage is an extremely important consideration.

During the initial mission in September 2015, the impacts of the Gorkha Earthquake on cultural heritage, including the Indra Jatra festival, were surveyed. In addition, during the November 2015 mission, cultural space was surveyed and inventoried using concrete urban spaces in the Khokana settlement. Cultural space is a crucial factor in ensuring traditional urban space preservation during recovery.

A summary of these results is included in Chapter 7. A detailed report on the intangible heritage in Khokana, titled “Survey on the Historic Settlement, Khokana”, was prepared separately.

Fig.1-5 Meeting with DoA

Fig.1-6 Meeting with UNESCO

Fig.1-7 Survey on traditional techniques of historic buildings

Fig.1-8 Structural survey of damaged buildings

Fig.1-9 Structural survey of damaged buildings-2 (3D measurement of Hanumandhoka)

Fig.1-10 Survey on emergency preservation measures (On-site workshop)

Fig.1-11 Survey of historic settlement

Fig.1-12 Survey on intangible cultural heritage

1.7. Invitation and interchange activities

To encourage information sharing between Nepal and Japan regarding the Gorkha Earthquake on 25 April 2015—the state of cultural heritage, activities performed to date, and future initiatives—a seminar titled 'Seminar on the Cultural Heritage Damaged by the 2015 Nepal Gorkha Earthquake' was held on 5 February 2016 at the National Research Institute for Cultural Properties, Tokyo (NRICPT).

As representatives of the cultural heritage protection agencies of Nepal, the Director General of the DoA-Ministry of Culture, Tourism and Civil Aviation (Bhesh Narayan Dahal); the Executive Director of HDMDC (Saraswati Singh) and the Culture Project Coordinator of the UNESCO-Kathmandu Office (Nabha Basnyat Thapa) were invited to attend. The seminar included presentations on post-earthquake conditions and recovery efforts by the Nepalese representatives and individual survey results by the Japanese project participants. While on-site conditions were still difficult, it was possible to exchange information and points of view through discussions regarding cultural heritage preservation measures.

On 5 February 2016 (the following day), seminar participants visited the repaired Sanbutsudo Hall of Rin'oji Temple and Yomeimon Gate in Nikko to provide the Nepalese representatives with a deeper understanding of historic building conservation techniques in Japan. They showed special interest in the conservation and repair of wooden members attacked by insects—a common issue in Nepal's cultural heritage. Through explanations provided by experts in charge of the repair work and other participating Japanese experts, seminar participants were able to discuss, question and exchange opinions.

Fig.1-13 Invitation seminar

Fig.1-14 Study tour at Sanbutsudo Hall of Rin'oji Temple in Nikko under restoration

2. Survey on Extent of Damage to Cultural Heritage

2. Survey on Extent of Damage to Cultural Heritage

2.1. Overall damage situation

2.1.1. Overview of the survey

In September 2015, the first survey was conducted to understand the damage caused to cultural heritage sites, especially to buildings designated as UNESCO World Cultural Heritage sites, and to select buildings to be investigated in the future. The damage was surveyed through observation and onsite photography; the buildings could not be studied from the inside for safety reasons. Because this survey was conducted more than four months after the earthquake, the removal of rubbles at the main sites was almost finished. Therefore, pre-survey information was obtained through interviews with people from relevant organizations and from the onsite reports of Prof. Kurotsu and Prof. Nishimoto, who were served as experts on “The Project on Rehabilitation and Recovery from Nepal Earthquake” conducted by Japan International Cooperation Agency (JICA) in June 2015.

In November 2015, the second survey was conducted to evaluate the damage at Hanumandhoka Palace in Kathmandu, which was one of the objectives of this project; Jaganath and Gopinath Temples, which were objectives of the project by the UNESCO Japanese Funds-in-Trust (JFIT); and the historical settelement of Khokana. Chapter 6 presents the survey results for Khokana, and Chapter 7 discusses the impact on the intangible cultural heritage.

2.1.2. Objectives of the survey

Kathmandu, the capital of Nepal, is located in the Kathmandu Valley. It has long been the political and economic center in the region. Furthermore, it is a sacred destination for Buddhism and Hinduism. The Malla Dynasty was established there in the 13th century. Then, the three kingdoms of Bhaktapur, Patan, and Kathmandu coexisted for a period. Finally, the unified Gorkha Dynasty was established in 1768, and it lasted until the monarchy was abolished in 2008. Throughout history, the former castle towns of the three kingdoms have had palaces and many historical religious buildings of importance in Hinduism and Tibetan Buddhism. The Kathmandu Valley was designated a UNESCO World Cultural Heritage site in 1979, including the three palaces and squares of the three kingdoms, two Hindu temples, and two Buddhist temples.

Kathmandu’s buildings are typically made of brick and wood, and their eaves and windows have fine carvings. The cityscape is characterized by peculiar combinations of building complexes with courtyards and towers at some places. The city houses various cultures that are distinguished by their religious complexes.

The Kathmandu Valley heritage site, as mentioned above, includes the following seven properties:

(1) Hanumandhoka Durbar Square, (2) Patan Durbar Square, (3) Bhaktapur Durbar Square, (4) Changu Narayan, (5) Swayanbhu , (6) Boudhanath, (7) Pashupatinath

The first survey in September covered the first six properties. The following four sites designated in the Tentative List of World Heritage sites were also investigated:

(8) Nuwakot Palace Complex, (9) Kirtipur (medieval settlement of Kirtipur), (10) Sankhu (Vajrayogini and early settlement of Sankhu), (11) Khokana (Khokana, vernacular village and its mustard-oil seed industrial heritage), and Bungmati adjoining it

2.1.3. Damage at each site

(1) Hanumandhoka Durbar Square

The most prominent damage caused to the royal palace was the collapse of the 7th to 9th floors of the nine-storied Basantapur Bhawan, which was built in 1769. Furthermore, other towers surrounding Lohan Chok were also damaged: the upper parts of Bhaktapur Bhawan located on the northeastern corner collapsed, and the top floor of Lalitpur Bhawan located on the southeastern corner inclined greatly. The evaluations conducted inside the palace revealed that the rest of this structure, including the courtyard, was damaged relatively slightly; this included the damage caused to the connecting points with adjacent buildings and to the eaves by fallen materials. The Shiva (Mahadev) Temple was the only building that collapsed completely in the square. Furthermore, inclined axes and partial collapse of buildings were seen over an extensive area. This included the southern building of Nasal Chok, Gaddi Bhaithak located on the southwestern corner, and 3–4 storied buildings, now serving as museums, that had been built in the Rana Dynasty. The upper part of the Panchamukhi Hanuman Temple located on the southeastern corner of Mohan Chok also inclined. In Aganchen Mandir that was built close to the north of Hanumandhoka Gate, the lower part that was rebuilt in the Rana Regime inclined considerably, and the tower built in the Malla Dynasty remained intact. Furthermore, Degu Talle Tower also inclined.

In the square in front of the royal palace, Narayan, Maju Dega, and Shivalinga temples, which were multilevel buildings standing on podiums; the three-storey octagonal Chasin Dega Temple; and Kastha Mandap, thought to be the origin of the name “Kathmandu” collapsed completely. In addition, most historical buildings in the square suffered some damage.

The removal of rubble was mostly finished by the time of the first survey, and reparation work was underway at Kumari Bahal. However, the lack of materials for temporal buildings or protective sheeting was obvious, and damaged buildings were left everywhere in the square. Some unsorted wooden members collected from collapsed buildings were also left on the ground.

Fig.2-1 Basantapur Bhawan, whose 7th to 9th floors were collapsed

Fig.2-2 Gaddi Bhaithak

(2) Patan Durbar Square

At Patan Durbar Square, the three-storey octagonal Taleju Temple and the highest layer of the three-storey Aganchen Temple in the southern building of Mul Chok were damaged. The Degu Talle Temple, which had collapsed completely in the 1934 earthquake, did not show obvious damage. The second and third floors of Sundari Chok, which was under repair, collapsed. The exhibition spaces of museums showed slight damage, as public displays were partially open in September. Restoration works began from an early stage in the Kathmandu Valley Preservation Project, and the materials collected from collapsed buildings seemed to be sorted orderly. Furthermore, a European team restored damaged statues. In the square in front of the royal palace, the three-storey Hari Shankar and the two-storey Char Narayan built on podiums and two buildings near the water place collapsed completely. Although the podium inside Char Narayan was dug to a deep level, the excavation was not systematic, leading to concerns over safety.

In the buffer zone of the old Patan city and the surrounding area, many temples had collapsed. This was mainly attributed to the lack of regular maintenance. I Baha Bahi, which had been restored previously by the Nippon Institute of Technology, did not suffer damage.

Fig.2-3 Collapesed east-wing of Sundari Chok

Fig.2-4 Restoring damaged statues

(3) Bhaktapur Durbar Square

Conspicuous damage was not seen in the buildings of Bhaktapur royal palace.

In the square in front of the royal palace, Basara Devi in Shikhara style built with stones collapsed completely, and its structural members were collected around it. Moreover, the central part of the south wing of the large hall (Pati) of Dharmashala, with an L-shaped floor, collapsed.

Many wooden towers in the old city showed little damage. Remarkably, the five-storey Nyatapola temple built on a high-podium foundation remained undamaged, in contrast to other towers that were damaged. Traditional houses in the buffer zone of the southeastern part of the old city showed massive damaged, and some areas were reduced to vacant lots. Therefore, recovering the historical townscape in the area seemed unlikely.

Fig.2-5 Basara Devi (Completely collapesed)

Fig.2-6 Nyatapola

(4) Changu Narayan

This Hindu temple built on the northern hill of Bhaktapur showed massive damaged. The upper layer of the two-storey corridor surrounding the main temple of the two-storey tower of Changu Narayan collapsed completely, and only the lower layer remained. The main temple and small tower of Kileshwar Mahadev located to its southwest were damaged at four corners of the lower layers and therefore became unstable, although the main temple was already restored in September. The removal of the temporal timber supports was questioned, because it seemed to be restored by simply laying collapsed bricks again. On the other hand, the wooden corner pole in the brick wall could be seen in the damaged part of the small tower, which might be valuable when studying construction techniques.

Fig.2-7 Changu Narayan

Fig.2-8 Kileshwar Mahadev

(5) Swayambhu

Swayambhu is a sacred Buddhist site on the western hill of Kathmandu. Although some vertical cracks were seen in the bowl-shaped roof of the great tower, they appeared to have been caused before the earthquake. No cracks were seen on the surface of the precincts on the hilltop. However, the risk of landslide was noted after the earthquake, and the surrounding buildings were collapsed or massively damaged. In the two towers of Shikhara style west of the great tower, the Pratapur Temple that had been repaired by DoA seven years earlier was damaged at the foundation. In the Anantapur Temple, one side of the tower collapsed, and the upper part of the other side was removed, leaving only the lower part. However, complete reconstruction was planned after removing the lower part. The small stupa at the entrance of the western approach, which had been reported to be damaged in June, was already repaired in September.

Fig.2-9 Pratapur Temple

Fig.2-10 Anantapur Temple

(6) Boudhanath

Remarkable damage was not seen on the outside of the great stupa of Boudhanath. The Buddhist monasteries around it were only slightly damaged. However, according to the DoA's investigation of the inside of the stupa, it was decided to repair the parasol-shaped roof above the flat top after removing it. The conservation work is currently underway.

Fig.2-11 Stupa of Boudhanath

Fig.2-12 The flat top that the parasol-shaped roof was removed

(7) Pashupati

Pashupati is a sacred Hindu site. In fact, people of other religions are not permitted to enter the precincts. Therefore, the damage could not be understood simply through remote visual observations. In many brick mortuary chapels around the precincts, damage such as collapsed domes was seen.

(8) Nuwakot

Nuwakot is a 3-hour drive away from Kathmandu, on the former trading rout to Tibet. It is famous for Sattale Durbar (Nuwakot royal palace), which King Shah established as a stronghold for the unification of Nepal. There is a settlement with around 25 houses along the street south of the royal palace, on the high ridge above the confluence of the valleys. Unfortunately, the entire settlement collapsed completely in the earthquake.

Sattale Durbar was built in 1762, prior to Basantapur Bhawan in the Hanumandhoka royal palace, and both structures have many commonalities. This seven-storey palace mainly showed damage in the upper layer, and the damage was similar to that in the Kathmandu royal palace. This building had been used as a museum until the earthquake under the DoA. It was repaired a few years earlier, and some signs of construction work could be seen on the timber. Plaster dropped from the surface of the inner walls during the earthquake, and some timber on the inside was exposed; these seemed appropriate places to investigate the construction. Two tower temples in the palace site were damaged so severely that the inner structure of the brick walls could be seen. The upper layer of the four-storey galat facing the royal palace was greatly damaged, and the third and fourth floors were already removed in September.

The two-storey main hall of Bhairab Temple located on the south edge of the town collapsed. Although the upper layer was already removed, the lower layer also faces the risk of collapse owing to the damage and inclination of the brick walls. This situation also seemed appropriate to investigate the inner wooden structure. The collected and dismantled members were kept under cover sheets in the precincts, and the carved materials of the eaves were kept in the palace. The structural timbers were also kept, so reconstruction while preserving the authenticity may be possible.


Fig.2-13 Sattale Durbar


Fig.2-14 Some timber was exposed from inside the wall

(9) Kirtipur

Kirtipur suffered relatively slight damage, because the tradition says that the town was established on a large bedrock. Conspicuous damage was not seen in the main historical buildings, including Bagh Bhairab, in the center of the old city. Although the city was surrounded by new buildings, there were still many historical buildings in the old city, and the former fortified cityscape was preserved. Therefore, it remains a very valuable cultural heritage site. However, little emergency aid reached Kirtipur because there were no earthquake victims here.

Fig.2-15 Distant View of Kirtipur located on the hill

Fig.2-16 Damage situation in Kirtipur

(10) Sankhu

The historical town of Sankhu was investigated with the support of the Swiss Government. The houses here showed severe damage. Few historical buildings remained, because some houses were removed to avoid their collapse. From the viewpoint of recovering the cultural heritage, it seemed very difficult to reconstruct Sankhu while preserving its authenticity.

Vajrayogini Temple located on the hillside north of the town is an important Buddhist temple, being the second older temple in Kathmandu following Swayanbhunath. An inclination was observed in the main mortuary hall, which might be attributable to differential settlements caused by the imbalance of the original strength of the ground. Some parts of the monastery quarters in the upper part of the temple were greatly damaged.

Fig.2-17 Damage situation in Sankhu

Fig.2-18 Vajrayogini temple

(11) Khokana and Bungmati

The historical settlement of Khokana suffered severe damage; in particular, the northern half of the main street suffered large-scale damage. Almost all houses had collapsed completely in the 1934 earthquake, and these had then been reconstructed. Their original structures suffered from many problems such as shared partition walls between houses and brick walls with poor strength. The strength of some houses seemed to have deteriorated owing to division and rebuilding.

Kokhana's traditional industry is mustard oil. The Kokhana Reconstruction and Rehabilitation Committee led by the local youth is acting vigorously for reconstructing the historical townscape.

The damage to the old town of Bungmati was so severe that three of four temples in the center collapsed. Leuven University in Belgium is suggesting a reconstruction plan for this place in conjunction with UN HABITAT (United Nations Human Settlements Programme).

Little damage was reported in Panauti, which is on the World Heritage Tentative List as a historical settlement in the Newar style.

Fig.2-19 Main street in Khokana after Gorkha earthquake

Fig.2-20 Damage situation of Khokana

Fig.2-21 Collapsed temples in the center of Bungamati

Fig.2-22 Damage situation of Bungamati

2.1.4. Summary of damage

(1) Degree of damage and its features

The earthquake caused extensive damage to historical buildings. Nonetheless, some typical damage patterns could be seen, such as inclination and collapse of the upper parts of towers and inclination of brick walls that were more than three storeys high. However, the damage in the historical town of Kirtipur was different from that in Sankhu, which may indicate regional differences in the strength of the ground and the intensity of the earthquake. According to detailed investigations of damaged buildings, in some cases, previous repairs had not made building sufficiently sound, and only superficial repairs were performed and differential settlements were left. Many investigations of damaged parts can now be conducted, such as the wooden construction technique in brick walls. It is necessary to clarify the cause and mechanism of damage through scientific approaches to conduct major repairs and find better reconstruction methods.

(2) Emergency aid and international support

Emergency aid for rescuing human life began immediately after the earthquake. Information about the damage caused to cultural heritage sites was collected with the support of UNESCO and ICCROM, and lists of buildings and their extent of damage were publically made available in one month. According to the Post Disaster Needs Assessment (PDNA) report published by the Nepalese government in July 2015, the total financial damage to tangible heritage was estimated as 16.9 billion Nepalese rupees, and the reconstruction budget was set as 20.5 billion Nepalese rupees over six years. Moreover, the restoration and reconstruction of cultural heritage sites was conducted under the direction of the DoA, and a collaborative system with relevant organizations including UNESCO was proposed in the report. According to the proposals, the Earthquake Response Coordination Office (ERCO) was established in the DoA. While the DoA proceeded with the bidding process for the reconstruction of damaged historical buildings, some organizations including UNESCO raised objections regarding the bidding methods.

Although some foreign countries had announced support for the restoration and reconstruction of cultural heritage sites immediately after the disaster, only few efforts began concretely. The reconstruction work of Panchamukhi Hanuman Temple in the Hanumandhoka royal palace has probably progressed the most; it has been conducted under the reconstruction committee established by Kathmandu city (the chairperson is the former director of the DoA), with the support of funds from the USA embassy. Although China has already signed memorandum with the Nepalese government for the reconstruction of Basantapur Bhawan, the building surrounding Lohan Chok in the palace, and Nuwakot royal palace, the concrete plans remain unclear. Although India initially showed interest in many issues, the relationship between the two countries has worsened after the establishment of the new Nepalese constitution, so whether India will join the project is not clear. Other undecided issues, as of March 2016, include the participation of Sri Lanka and Germany in the reconstruction of temples at the center of Bungmati and Bhaktapur, respectively.

On the other hand, the Kathmandu Valley Preservation Trust (KVPT) has already offered to take charge of the reconstruction of buildings that it had reconstructed before, and it provided a budget for the reconstruction of almost all buildings. The Japanese government offered scaffolding materials to KVPT as part of the grant aid.

2.2. Investigations of damage to World Heritage Sites in Hanumandhoka

2.2.1. Purpose of investigation

Many historical buildings around Hanumandhoka Durbar Square in Kathmandu were damaged severely by the Gorkha earthquake. Many towers collapsed, and some inclination or collapse of columns or brick walls was seen even in the other buildings that did not collapse completely. Almost all buildings included in the World Heritage List were damaged, and therefore, investigations and analyses of the condition, form (style), and relation with the construction date of each building are necessary for the reconstruction.

Nepal has historically had a distinct culture despite the influences of the cultures of India and Tibet. The architectural features in Nepal show many similarities with those of Japan. Moreover, the Nepalese tradition of reconstructing damaged buildings by reusing materials is similar to that of Japan, which also suffers from earthquakes. Nepal and Japan share a similar culture in this manner. Therefore, in this project, we will make proposals for improving the earthquake resistance and safety, analyze the structural features of tower architectures, and provide technical support for investigation, documentation, and arrangement to establish conservation and reuse methods for wooden materials to reconstruct damaged buildings based on studies on historical buildings and restoration techniques for buildings as a cultural property in Japan.

Buildings were damaged to varying degrees by the earthquake over a wide area. Therefore, a thorough investigation of the damage through observation, target selection, and a case study about the reassembly of members should be conducted at the Hanumandhoka Durbar Square to ensure the objectivity and versatility of the proposals and to share the results of reconstruction works that will be conducted in future. This can be achieved through cooperation with the DoA and MDC.

2.2.2. Damage to the royal palace

The palatial buildings of Hanumandhoka comprised nine Choks built between the 17th and 19th centuries. The architectural styles are of the Malla, Gorkha, and Rana Dynasties depending on the construction dates. However, they are similar in terms of having three-storey buildings around a courtyard (Chok) and towers (Mandirs) at corners. Each building has a structure made of brick and wood, and it is roofed by a traditional pantile or copper-ribbed seam roofing.

The buildings of the royal palace were greatly damaged in the last earthquake. The collapse of the upper layer of the nine-storey Basantapur Bhawan at the southwestern corner of Lohan Chok and the damage to the façade of the building in Durbar Square (now used as the national museum), which had a

British design and was built during the Rana Dynasty, were widely reported in the media as symbols of the disaster. At the same time, the damage in the royal palace was not well understood. This is because, being the quarters of the former royal family and containing many religious buildings, entry to many parts of the palace was limited.

Thorough investigations were conducted to understand the tendencies of damage to traditional buildings and to select targets for detailed individual investigation. The survey relied on observations. The degree of damage was classified into four categories: Total collapse, Partial collapse, Breakage, and Without breakage (Fig. 2-23).

a. Lohan Chok

Among the towers at each corner, the upper layers of Basantapur Bhawan at the southwest corner and Bhaktapur Bhawan at the northeast corner collapsed, and the eaves of the lower layers around them were greatly damaged. The top floor of Lalitpur Bhawan at the southeast corner inclined toward the south. In each building in the Chok, differential settlements or inclinations and separation of walls at corners or junctions were seen; in particular, the damage at the southern side facing the square was remarkable.

b. Mul Chok

Although the situation was relatively safe, the roof and eaves of the southwest part were greatly damaged following the collapse of the upper layer the Bhaktapur Bhawan.

c. Sundari Chok

Cracks and inclines were observed on entire walls, and the balconies of the west and north parts of the surrounding wall suffered remarkable damage.

d. Mohan Chok

Remarkable cracks and inclinations were seen in the western wall of the surrounding that connects to Sundari Chok; considerable inclinations and subsidence of brick walls that had been built as a series of buildings with Aganchen Mandir were observed; and the walls were largely separated from the northern part. The wooden columns in the three stories under Aganchen Mandir inclined largely toward the west, and the junctions to adjacent building were separated; the upper layer seemed relatively safe. Deformation following subsidence was observed in the eastern surroundings.

e. Masan Chok

Irregular sinking and inclination of walls were remarkable at the outer wall of the western buildings facing the main street. Deterioration and cracks on the walls of junctions were seen over time inside the building; however, the earthquake did not cause any damage except for flaking plaster in the eastern part. The three-storey tower at the center of the courtyard inclined, and the brick walls of the lower layer partially collapsed.

f. Dakh Chok

Degu Talle Temple in the northwestern corner inclined toward the east, and the highest part of Degu Talle inclined toward the west. The junction to the buildings of Dahak Chok was largely separated. Cracks on the walls, flaking, and inclination of the plaster wall were observed in all buildings of the Chok. The southern inner wall of the second floor was protruded largely.

g. Nhulchem Chok

The ornaments of the European-style surroundings in the southwestern corner built in the 20th century suffered severe damage, and the pediments and cornices of the pillars collapsed. In the western surroundings connecting the part described above, separation of the junction and roof collapse occurred.

h. Lamo Chok

Cracks were seen at the highest point in the southwestern corner were seen, and the entire southern outer wall of the first and second floors was inclined.

i. Nasal Chok

Following the collapse of the upper layers of Basantapur Bhawan in the southeastern corner, the eaves in the adjacent Chok were greatly damaged. Panchamukhi Hanuman in the northeastern corner inclined toward the north, and the roofs of each layer became remarkably uneven. On the other hand, the northern and northeastern parts inside the building suffered only slight damage. The plaster wall suffered cracks and flaking in the western part, and a large vertical crack penetrating all layers of the brick wall was observed. The inclination of the southern wall became remarkable. Cracks and unevenness were observed in the entire southern wall and southern part of the eastern wall. The separation of the corners joining to other buildings was remarkable.

j. Others

The area east of Mul Chok, where the Shiva and Dasain Ghar temples are located, is a part of the royal palace, and entry is prohibited. Although the Dasain Ghar Temple was hardly damaged by the earthquake, the Shiva Temple collapsed completely.

2.2.3. Damage at Durbar Square

Durbar Square contains World Heritage sites along with the royal palace. These buildings were damaged more severely than the royal palace. Eight buildings, including Narayan and Maju Dega Temples, which are famous sights in Hanumandhoka Durbar Square, collapsed, and more than 20 buildings suffered partial collapse and needed quick repairs to the inclination of the axis and brick walls.

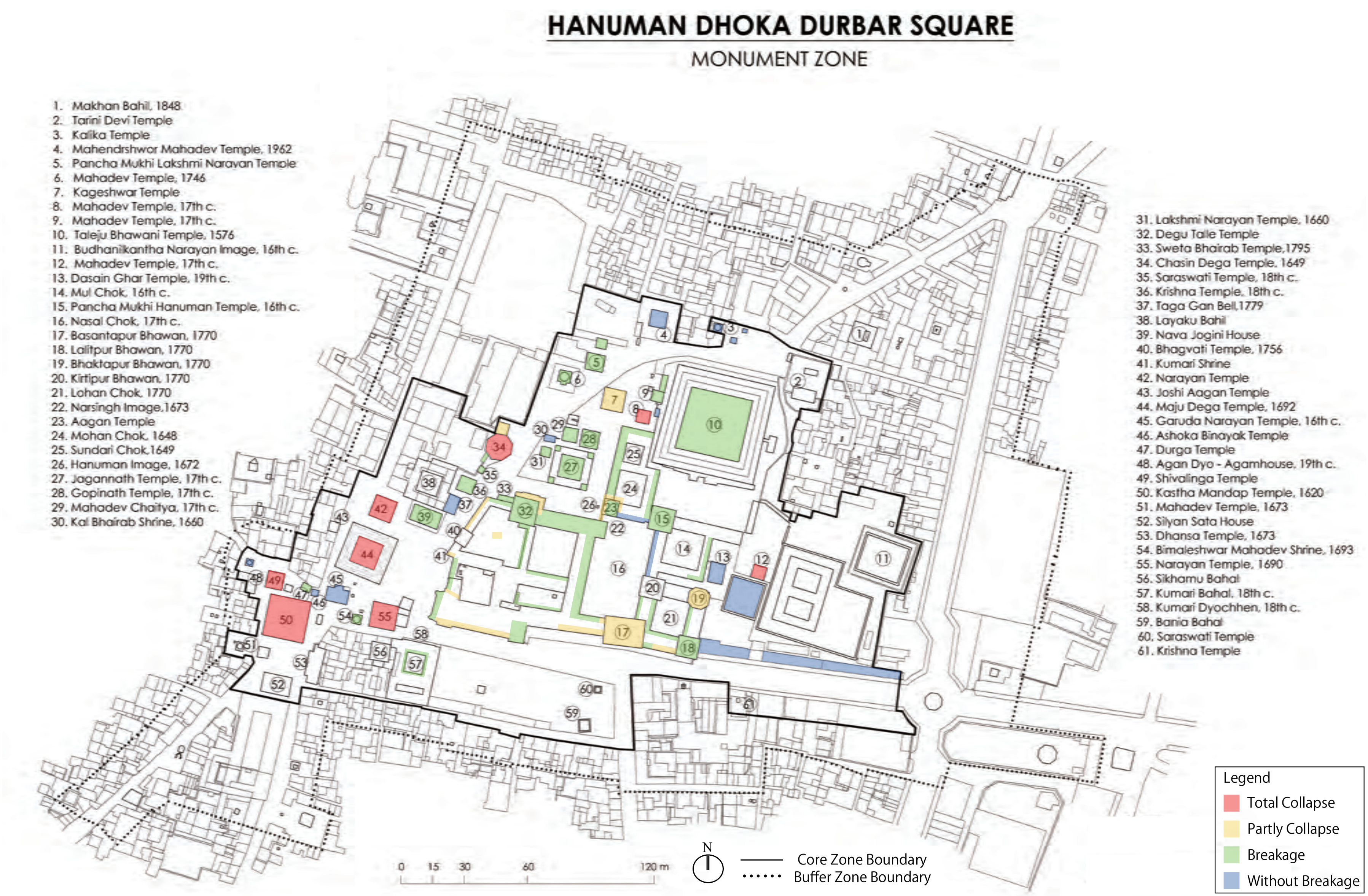


Fig.2-23 Thorough investigations in Hanumandhoka Durbar Square (Based on the map offered by UNESCO-Kathmandu Office)

(1) Collapsed buildings

Collapsed buildings were concentrated in the northwestern part of the royal palace. Here, four buildings collapsed, including Narayan and Maju Dega Temples and Kashtha Mandap; these are three-storey buildings on high step-shaped podiums with free-standing pillars surrounding the lowest layer. Three-storey towers with brick surrounding walls at the lowest layer, such as Taleju Bhawani and Gopinath Temple (Srikrishna Mahavishnu Temple), suffered slight damage, and there were some tower architectures with openings at the surroundings that suffered no damage in other areas. Therefore, it is necessary to investigate the bedrock, states of inner frames, and pre-earthquake conditions (repair works conducted in recent years).

Now, all collapsed materials have been removed and only brick podiums remain. Wooden members were collected and covered with sheets between Gopinath and Jaganath Temples or west of the Nava Jogini House, which were at a distance from tourists' main routes; however, the long pillars of Kashtha Mandap were placed to the side of tourists' main routes in the square.

(2) Partially collapsed buildings

In most buildings, partial collapse, inclination, or unevenness of brick walls was observed. In particular, in small towers built around Taleju Bhawani and Jaganath Temple, large inclination and torsion of the brick walls were caused because they were small.

Other than tower architectures, Nava Jogini House built on a high podium inclined greatly, and inclination or separation of walls of buildings in Kumari Bahal was observed. However, they were used as usual after being supported by temporal materials; however, the risk to human life by aftershocks then became a matter of concern.

Fig.2-24 Damage situation of the south of Nasal Chok and Lohan Chok

Fig.2-25 Damage situation of inner walls of the Nasal Chok

Fig.2-26 Damage situation at the veranda on the second floor of Mohan Chok

Fig.2-27 Nagpukhu, East side of Hanumandhoka

Fig.2-28 Kageshwar temple whose upper floor was collapsed

Fig.2-29 Salvaged members compiled under the porch of Dakh Chok

Fig.2-30 Salvaged members gathered next to Gopinath Temple

Fig.2-31 Salvaged Members from collapesed Shiva Temple

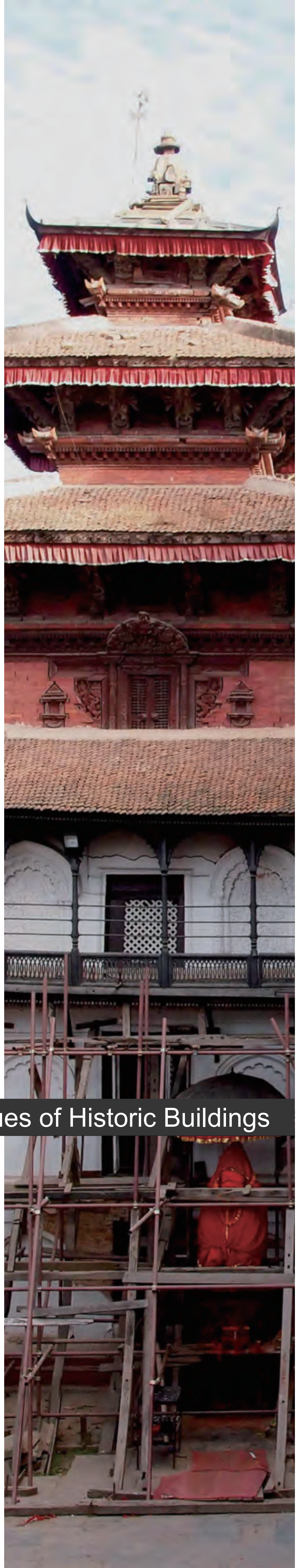
2.2.4. Selection of buildings for detailed investigation

After the above-described thorough investigations, Aganchen Mandir in the southwestern corner of Mohan Chok was selected for a detailed investigation; this building showed damage characteristic of that suffered by the royal palace buildings. It had been changed little through history until recently, and it seemed appropriate for understanding the damage to a traditional structure. Moreover, investigations at the inner parts of the lowest three layers and joint state with the adjacent Chok were conducted with the cooperation of the MDC (see Chapter 3).

Gopinath and Jaganath Temples were selected for structural investigations. These were tower architectures that were built independently and that suffered great damage. Internal investigations were permitted by the DoA and administrators. Investigations such as microtremor measurements and 3D scanning were conducted (see Chapter 4).

Because saving human life was prioritized immediately after the disaster, members from some adjacent collapsed buildings were collected and stored. However, these got mixed; they were piled up without sorting in the balconies in the lowers layer of the Chok or courtyard in the royal palace and on the street next to buildings away from the main routes in the square. According to an investigation of the stored timbers, collected timbers included only carved ones, and many undecorated long timbers such as members from the eaves were reused as temporal support timbers for inclined buildings. On the other hand, almost all timbers of the Shiva Temple east of Mul Chok, which collapsed completely, were collected at the same place without mixing with those of other buildings, because there are no other temples near the Shiva temple. It was judged that investigating and understanding the entire structure in a limited period were possible, because the temple was relatively small. Therefore, it was selected as the object for the arrangement, sorting, and storage of timbers (see Chapter 5).

(Chapter authors: Masahiko Tomoda, Tadatsugu Tai, and Takayuki Kurotsu)



3. Survey of Traditional Techniques of Historic Buildings

3. Survey on the Traditional Techniques of Historic Buildings

3.1. Introduction

We can find historic buildings from the medieval *Malla* and *Shah* periods remaining in Kathmandu Valley. Royal palaces consist of buildings organized around an inner courtyard called *Chok,* and towers called *Mandir*; together with the temples standing in the squares in front of the palaces, they form groups of buildings built with timber and brick (Fig. 3-1). These buildings show an architectural style which is original in South Asia, with features such as deep eaves with inclined timber roofs, roof tiles, brick walls, windows with carved wooden frames, carved wooden pillars, and struts decorated with statues of gods. Last earthquake, which had its epicenter in Gorkha (hereafter referred to as "Gorkha Earthquake" in this chapter) has caused an enormous damage to these historic buildings. As explained in Chapter 2, the damage was concentrated in *Hanumandhoka*, the royal palace of Kathmandu (Fig. 3-2). The conservation and repair of the buildings of this royal palace, which is a key spot for tourism as well as part of the World Heritage area, is a matter of the utmost urgency.

Apart from emergency repairs of the architectural heritage, an understanding, research and survey of the traditional building techniques is essential in order to make possible a repair an restoration that does not harm its value as a cultural heritage. While there has already been international support in the form of funding, the actual recovery of lost architectural heritage requires a long-sustained effort. The first step should be taking emergency measures for the stabilization of partially collapsed buildings, using techniques suitable for Nepal.

Fig.3-1 Aerial view of Kathmandu Royal Palace (Hanumandhoka) before the earthquake, 1965 (photo by Ganesh photo Lab)

Fig.3-2 View of Kathmandu Royal Palace (Hanumandhoka) after the earthquake, June 2015 (photo by T. Kurotsu & JICA)

3.2. Outline of the survey

The authors of this chapter were in charge of the survey on the extent of the damage and on traditional building techniques. First of all, we would like to express my gratitude to the DoA, the Hanumandhoka Durbar Museum Development Committee, as well as the national and foreign organizations that made this survey possible. Regarding the survey on the extent of the damage, we carried out a preparatory survey in November and March as a part of this program, based on an on-site visual inspection after the earthquake carried out in June as a JICA mission (mainly on the 7 areas that constitute the World Heritage Site), and an on-site survey carried out in September as a mission of the Nippon Institute of Technology (mainly on royal palaces and Buddhist monasteries on mountain areas). From this preparatory survey, we will focus on the historical assessment and extend of damage of the Aganchen Mandir (hereafter referred to as Aganchen Temple) in Hanumandhoka. As for the survey on traditional building techniques, we will give an overview of the repair works carried out in Hanumandhoka after the earthquake, our understanding of traditional building technology based on experiences of repair works, and the present situation of the production of timber and bricks.

3.3. Typologies of Newar architecture

Many of the historic buildings in Kathmandu Valley were built by the Newar people during the medieval Malla and Shah periods. The UNESCO heritage inventory ("Kathmandu Valley, the Preservation of Physical Environment and Cultural Heritage a Protective Inventory", 1975) lists up 888 buildings (including the Historic Palace Estates built during the Rana regime). We can classify these buildings according to their typology as shown in Fig. 3-3. The buildings totally or partially collapsed during the Gorkha Earthquake belong to the following typologies:

Temples and royal buildings:

Shikhara style stone towers (Hindu temples), multi-tiered towers (with two, three, or five storeys), high-rise pavilions with a lookout point on the top floor, buildings organized around an inner courtyard (Hindu monasteries, urban houses), pati resthouses, mandap resthouses.

Urban facilities:

As I mentioned above, the damage to historic buildings was concentrated on Hanumandhoka, the royal palace of Kathmandu, where we can find representative examples of Nepali architecture. These include Maju Dega, a three-storey temple built on top of a podium (1692), Basantapur Bhawan, a nine-storey pavilion that rises over a building with a courtyard (1769), Kastha Mandap, a large wooden tower (1620-39), and Mohan Chok, a building with an inner courtyard which was originally built in the Malla period but was largely restored during the Rana regime. Although Fig. 3-3 does not show the royal palace buildings westernized during the Rana period, the condition of Gaddi Bhaithak (1908) and other buildings with white walls is close to total collapse, with generalized damage to the whole brick wall, even though the buildings are still standing.

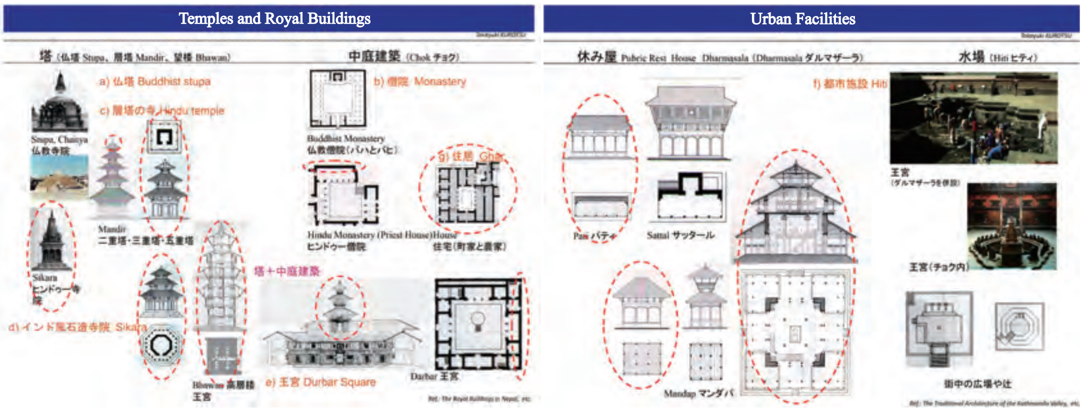


Fig.3-3 Typologies of Newar architectures

3.4. Features and materials of traditional construction

3.4.1. Repair works at Hanumandhoka

Many buildings are being prevented from collapsing by timber props deployed all over the outer wall. These props are long members such as rafters and floor joists salvaged from temples, and many of them are old. Old members without decoration are attached to the walls as props. The base of the props is fixed with round steel stakes to prevent them from sliding outwards. The rest of the members from collapsed buildings were piled up at the Durbar Square until June, and then stored in different places in preparation for the rainy season. Carved members, on the other hand, were piled up in the courtyards of the royal palace and covered with protective sheets. By November, the sorting and storing of salvaged members had already started, and in March window frames were being temporarily reassembled. The sorting of members by building has been mostly completed, but the original position of the elements in each building will still require examination.

The activities led by DoA are progressing without setbacks. The emergency installment of timber props protected the architectural heritage from the aftershocks, but the time has come to execute emergency repairs, especially in the case of partially collapsed multi-tiered buildings and courtyard buildings. From a very early stage, there were buildings with scaffoldings awaiting repair. However, the state of the repair project and the survey remains unknown.

Two buildings are actually being repaired: Degu Tale (a large three-storied tower, hereafter referred to as Degu Tale Temple, Fig. 3-4) and Panchamukhi Hanuman Mandir (hereafter referred to as Panchamukhi Hanuman Temple, Fig. 3-5). Both of them are being repaired by DoA, and the work carried out seems to be conservation and repair of the damaged parts. While we want to express our admiration for the promptness with which they started, we have not obtained any information about the works being carried out. At first glance, in the case of Degu Tale Temple, the wall of the third storey (where the three-storey tower is standing) is being raised again (mainly the northeast corner of the east side) and the roof of the eaves is being rebuilt. The traditional practice of curing the bricks with water before piling them up again is being employed. White dots, presumably efflorescence, can be observed on the surface of the already piled up bricks. The quality control of the materials is a matter of concern. The joints are made of mud mortar mixed with powder from bricks (it is unclear if there is lime in the mix) and there is an effort to achieve cohesion with the existing wall. In the case of Panchamukhi Hanuman Temple, the repair works consist of reroofing of the roof tiles, rebuilding the outer wall, and repairing wooden members. The leaning rooftop pinnacle (*gajū*) has been dismounted and will presumably be reinstalled. We would like to watch if the extent of the repair reaches the south wing of Mohan Chok beneath. While the repair is an emergency one, we felt certain issues regarding the handling of old material and the fact that sound parts were being demolished in order to set the scaffolding. We were informed that the person in charge of the works is taking record pictures and videos. Nevertheless, there are many points we would like to check, such as the selection of materials employed in the repair, and the methodologies applied in the previous repair work. We hope that in the future the works advance in a coordinated way and information is shared.

3.4.2. Features of the traditional building system

Newar architecture uses timber and brick as building materials (Fig.3-6). Buddhist monasteries have a nearly square plan, with two-storey buildings surrounding an inner courtyard. They have rows of pillars to the courtyard side, and brick walls to the outside (Fig. 3-7). The brick walls are raised on top of a continuous foundation. A wall plate is laid on top of the inner and the outer wall, closely spaced floor joists are laid between walls, floorboards are laid on top of them, and the flooring is made with compressed clay. A feature of buildings from the Malla period onwards is that timbers are used with the longer side of their section laid horizontally. The second storey has also brick walls and a clay floor with a wooden structure. The structure consists therefore of units of the same section with a horizontal earthen floor piled

Fig.3-4 Restoration of Degu Tale

Fig.3-5 Restoration of Panchamukhi Hanuman

up together. The roof structure is made of timber, with a simple structure made of posts supporting the ridge, and rafters. Tiles are used as roofing material. The roof is gabled and the rafters are also closely spaced. Wooden boards are placed on top of the rafters, and clay is laid on top of them. The tiles are just placed on top of the roofing clay. Thus, the roof is actually an inclined clay floor. The eaves are deep and the connections between members are made with wooden square pegs.

The openings on the walls have frames in a horizontally long “II” shape, with the lintel and the threshold projecting to the right and left of the jambs. Entrances (doors) and windows with carved wooden frames are opened in the brick walls. The surface of the openings is relatively small compared to that of

Fig.3-6 Aerial view of Kathmandu Royal Palace (Hanumandhoka) before the earthquake, February 2015 (photo by T. Kurotsu and JCIC-Heritage)

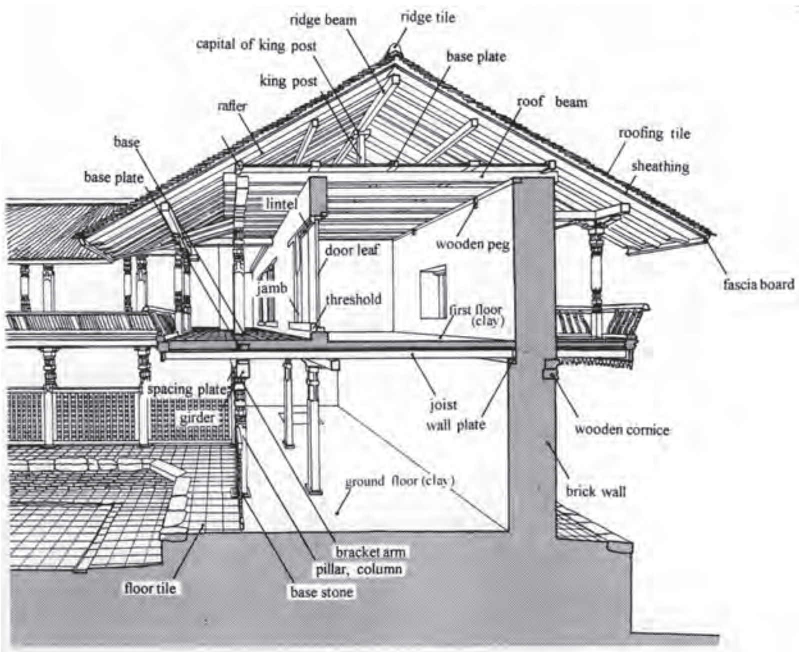


Fig.3-7 Traditional structural system (example of I Baha Bahi Buddhist monastery) (from *The Buddhist Monasteries of Nepal,* Tokyo, 1998)

the wall. In some cases there are latticed windows (like balconies) and typologies with brick walls also to the courtyard side. In the Rana regime (from the middle of the 19th century) windows become larger and vertical, and the spatial connection between courtyard and inner space becomes weaker.

Multi-tiered towers present the following typologies: buildings with a square plan, with four brick walls surrounding the space of the god, buildings with an outer brick wall or a row of wooden or stone pillars surrounding the square inner core, and buildings with a rectangular shape that include space for the monks or prayers. These large towers have a wall running through the middle, dividing the rectangle plan in two parts. High-rise pavilions with a lookout point on the top floor usually have a brick wall (hereafter referred to as master wall) in the lower levels that supports the upper storeys. However, there are many typological variations among multi-tiered towers and high-rise pavilions, and in some cases the master wall is substituted by a row of pillars in the upper floors in order to make a unified space inside.

During the royal dynasty, a rule prohibited building structures higher than Taleju Bhawan. However, building high rise structures by piling up bricks was surely a great technical challenge for the builders. In order to make possible the progressive reduction in the size of the roofs, the outer walls have a stepped section, where the outside surface of the wall retreats as the wall goes up. This is possible because brick walls are raised directly on top of the floor joists. In addition, pillars embedded inside the walls and horizontal members inserted in the middle of the wall have been spotted in the damaged buildings. These are valuable clues to understand the building techniques employed to combine the brick and the wooden frame.

The defining features of Hanumandhoka were the three-storey towers raised on top of high podiums, the numerous towers standing in the Durbar Square like a forest, and the building with courtyards and small towers on their roofs. We would like to leave the explanation on the relationship between buildings with courtyards and multi-tiered towers for the next report after the following surveys.

3.4.3. Timber and bricks

The concrete knowledge about Newar building techniques has been gained through conservation and restoration works. The main structural materials are timber and brick. Employed wood species are sal (*Shorea robusta*) and chir pine (*Pinus roxburghii*, locally known as *agrākh* and *sallā*). In addition, the *gvālchāsĩ* (chirauni) of the *Theaceae* family and the ring-cupped oak (*Quercus glauca*) of the *Fagaceae* family are also used. Sal, a hardwood, is widely employed in architectural members such as pillars, purlins, struts, and door leaves for its excellent resistance to water and its durability. Chir pine is relatively lighter and employed for long members, such as floor joists, roof beams, and rafters.

It is not possible to obtain long size timbers in lumber stores in Kathmandu City, but is probably possible to import them. In lumber stores, thin sal wood boards up to 9 feet long can be found. It is also easy to find chir pine members up to 2-3 meters long. Thus, it is an issue to find good quality long size members for their use in restoration work.

Bricks are made with wooden moulds, and can be sun dried or fired bricks burnt in a kiln. There are two types of fired bricks: *māapā*, which are the main material in structural walls, and *dātiapā*, which are used as finishing material in the outer walls. *Dātiapā* bricks are shaped like a wedge, leaving a space for the joint to the inside of the wall and no joint to the outside. In addition, there are roof tiles and floor tiles (*cikãapā*). There are also some roofing tiles, such as *ãypā* or *jhīgatī*, which have a rail for a hook and a protrusion, and *gvāgaḥcā*, which are shaped like a bird and used in the corners.

These bricks are produced using traditional technologies still today, and it is possible to see these brick factories. Many factories are mechanized and have horseshoe-shaped kilns that make mass production possible, but these are factories for general construction bricks. Brick production is still intense during the dry season. The pictures show a traditional brick factory in Bhaktapur (Fig. 3-8, Fig. 3-9) where *māapā* and *dātiapā* bricks, which are still under demand, are made by hand. The brick kiln is made in a place with abundance of grey clay; clay is excavated from the fields, refined with water, and stirred with a machine. There were about 20 female workers, and they performed tasks such as making the wooden molds, sun drying the bricks, and reshaping them. The brick kiln was shaped like a vault and allowed for good quality production. It is dubious if good quality clay will still be obtainable in the future, but for the moment it is possible to obtain traditional bricks for restoration work. There are certain factories that have old-style kilns, but managing the temperature in these kilns is difficult, and there is a need for further surveys on the present state of the production techniques.

(Sections 1, 2, and 3 author: Takayuki Kurotsu)

Fig.3-8 Female worker manufacturing *dātiapā* bricks

Fig.3-9 Taking out *dātiapā* bricks from the brick kiln

3.4.4. Soft walls

The most prominent feature of traditional architecture in Nepal is the brick masonry wall. The masonry technique of the outside of the wall, where bricks are laid without joints, gives the outside its characteristic appearance. However, to the inside a different brick laying technique and bricks with different sizes are employed. This technique requires a careful study.

An explanation of masonry walls can be found in W. Korn, *The Traditional Architecture of the Kathmandu Valley*, Bibliotheca Himalayica Series III, Volume 11 (Kathmandu: Ratna Pustak Bhandar, revised ed. 2007. First published in 1976), pp. 148-151. Here, it is pointed out that "the use of mud mortar; poor bonding between the facing brickwork and the backing brickwork" (p. 150). In regular brick masonry, bricks are joined together with mortar in order to give unity to the wall. However this is not achieved here.

A similar explanation can be found in Nippon Institute of Technology, Research Mission for the Study of Old Royal Palaces of the Kingdom of Nepal, *The Royal Buildings in Nepal: A Report on the Old Royal Palaces of the Kingdom of Nepal* (Tokyo: Chuo Koron Bjutsu Shuppan, 1981), pp. 107-111: "1. Mud mortar is used to set the bricks. 2. Baked bricks are employed where they are going to remain seen, behind them, low quality bricks or adobe bricks are employed, and their sizes and quality vary greatly. For this reason, cracks appear on the outer side of the wall, and the outer bricks peel off" (p. 108).

On the other hand, the timber structure is designed to allow displacements. This suggests the possibility that the structure is not designed to be rigid, but rather to absorb the earthquake energy through a vibration control system.

It is possible that the same idea lays behind the roofing technique, where small sized tiles are simply laid on a clay layer. It can be thought that this design was intended to allow the tiles to fall down in the case of an earthquake in order to make the roof load lighter.

The building technique in this region can be understood as a wooden frame filled with brick masonry. However, this brick masonry is quite unique, since bricks are set with mud and there is no turn the wall into a single rigid body. We could say that buildings have soft walls. It is necessary to think again the reason behind this building technique.

These buildings are often understood as having a mixed structure made of timber and brick. However, we can also think that these brick masonry soft walls behave as dampers during an earthquake. We have to hope that further structural analysis of traditional architecture is conducted in order to clarify the unique building technique of Nepal. If we study the timber frame and the brick masonry separatedly, we can easily come to the conclusion that the frame is insufficiently tied and the masonry is careless. A deeper and comprehensive analysis is requires to reveal the true meaning of the building techniques in Nepal.

This kind of structural analysis is highly developed in Japan, and we can hope to obtain important results.

(Section author: Shinichi Nishimoto)

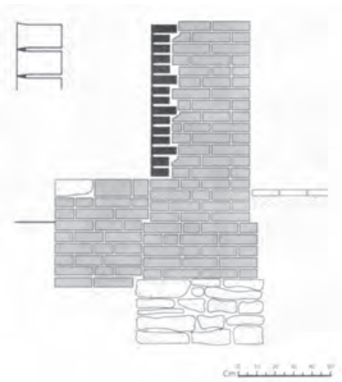


Fig.3-10 Wall section (from Korn, p.149)

Fig.3-11 Finishing *dātiapā* bricks (Swayambhu)

Fig.3-12 Roof tiles (Durbar Square)

3.5. Two-storey towers pagodas with pillars embedded in the wall

From the structural point of view, a feature of traditional architecture in Nepal is the use of a mixed timber and brick structure. It is not a simple masonry structure; rather, the masonry is combined with a timber structure, and brick and timber cover each other's shortcomings.

Bhairab Temple in Nuwakot is a small two-storey temple (Fig. 3-13, Fig. 3-14). As a result of the Gorkha Earthquake, the second storey was menacing to collapse and was dismantled. Currently, only the first storey can be observed.

The First storey has a 500-600 mm wide brick wall on four sides. The earthquake damaged part of it, revealing timber pillars embedded inside. There is a 22 cm wide square pillar in each corner of the brick wall, and the distance between pillar centers is about 3.6 m in the east-west direction and 2.9 m in the north-south direction.

The brick wall covering the pillars to the south side is heavily damaged (Fig. 3-15) and the whole building has a residual deformation in the east-west direction (Fig. 3-16). The joints between bricks are thin and weak, and the brick wall cannot be expected to behave as a unity. Observing the joint between pillars and beams/purlins, it can be deduced that they are joined with short tenons (Fig. 3-17).

Thus, the brick wall is insufficient as a masonry structure, and the timber frame is unable to resist moment and has low seismic resistance. However, both elements combined possibly had enough resistance to narrowly avoid collapse.

A large proportion of the horizontal seismic load is transferred to the high rigidity brick wall through the friction between the timber frame and the brick. Although the weak joints were the cause of the heavy damage, the timber frame may have worked stabilizing the brick wall as a fail-safe mechanism.

Clarifying the behavior and mechanical properties under seismic loads of the mixed timber and brick architecture of Nepal will provide a useful knowledge to conserve and restore the buildings. Testing of the mechanical properties of structural materials and numerical simulation analysis will also be necessary.

(Section author: Manabu Ueda)

Fig.3-13 Approach to Bhairab Temple (Nuwakot)

Fig.3-14 Outside view of Bhairab Temple. The corner pillar has fallen down, but the building has not collapsed completely

Fig.3-15 Pillar embedded into the wall at the southwest corner

Fig.3-16 East side brick wall. The wall is visibly inclined to the west, the outside dātiapā bricks have fallen down

Fig.3-17 Pillar embedded into the wall, Bhairab Temple

3.6. Historic assessment and extent of damage of Aganchen Temple

3.6.1. Historical assessment

The royal palace of Kathmandu is called Hanumandhoka, which means “Gate of the Monkey God”. A statue of Hanuman made in 1672 is located next to the main gate. This main gate was also formerly called Suvrnadhoka (“Golden Gate”). The object of the survey in this project, aimed at providing post-earthquake technical support to the country, is Aganchen Mandir (Aganchen Temple), a three-storey tower located in the oldest section of the palace (Fig. 3-18). The 50 m long facade that goes from the main gate to Mohan Chok, including this three-storey Malla period tower, can be regarded as a masterpiece; and although alter during the Rana period, it is a symbol of the power and prosperity of ancient times.

An inscription on a board in Mohan Chok, located below the Aganchen Temple, identifies King Pratap Malla as the builder and the construction date as 1649. We can assume that Aganchen Temple was also built at this time. Aganchen means “house of the private god” in Newari. The god housed in this tower is Taleju, the guardian deity of the royal house, kings prayed here to him in secret (Fig. 3-20). The King could gain the power to control the Taleju god through a mantra. Mohan Chok and Sundari Chok located to the North were the places were kings were born and died. The inner courtyards of Mohan Chok and Sundari Chok have a fountain for ablutions excavated in their center. Thus, we can think of Aganchen Temple a shrine integrated into Mohan Chok, the center of political, religious and daily life of the Malla kings. It has a special significance even among the royal palace buildings.

From the outside, Aganchen Temple appears to be placed on top of the roof of the main gate of the royal palace. However, its structure actually begins inside the roof (4th storey) of the southwest corner of the west wing of Mohan Chok. The struts with carved gods and torana (semicircular wooden board) that decorate the exterior of this three-storey tower have carvings of superb level, attesting the fine quality of the architectural design. The struts under the eaves are decorated with male-female mithuna couples; the kunsar sacred animals that protect the four directions in the corner struts also appear in pairs (Fig. 3-21).

Fig.3-18 Hanumandhoka, main gate façade (main gate on the right bottom, the three-storey building with white walls is the west wing of Mohan Chok)

Fig.3-19 Hanumandhoka west wing façade, including the main gate

Fig.3-20 Aganchen Temple, first storey, east side (seen from the inside of the roof of the south wing of Mohan Chok)

Fig.3-21 Aganchen Temple, first storey, east side (the strut to the left is kunsar)

The building also presents an original design among the royal palace complex buildings, with details that cannot be found in other mandir such as the shikhara style pinnacle (gaju).

There is also an Aganchen Temple in the royal palace of Patan, but it was destroyed in the 1934 earthquake (according to previous research). Thus, this building is the only one remaining that bears this name. Both were three-storey towers, but the remaining one has a square plan of 4.2 m while the lost one measured 2.55 m; thus the Aganchen Temple of Hanumandhoka is significantly larger. There is an Agam Mandir on top of the center of the south wing of Mul Chok in Patan Royal Palace, but its relationship with the lost Aganchen is unclear.

Mohan Chok, with Panchamukhi Hanuman Temple standing on the northeast corner, and the small tower on the northwest corner, retains well the chokwath style typical of the Malla dinasty. It can be said that the three-storey Aganchen Temple has a special historical significance among the royal palace buildings of Nepal.

3.6.2. Extent of damage

Aganchen Temple stands on top of the west wing of Mohan Chok, whose outer wall is significantly leaning towards the Darbar Square. The brick masonry wall has collapsed, pushing the bricks outwards (Fig. 3-22). The damage is especially notorious around the openings below Aganchen Temple and the connection with the west wing of Mohan Chok. The outer wall brick masonry and plasterwork are later additions, but it is possible that bricks from the original construction remain inside the wall. This is a fundamental factor in the assessment of the value of this building, and an important question in order to decide the repair policy. It is a point that should be clarified at the time of the execution of the repair.

The space inside the first, second and third storey below Aganchen Temple (the southwest corner of the west wing of Mohan Chok) is occupied by rooms. There are 10 inner pillars with brackets on top supporting the beams and the load from above (Fig. 3-23). They are presumed to be later additions introduced as reinforcement (they will be hereafter referred to as “later pillars”) and are notoriously leaning towards the square in all three storeys. In the first storey, the maximum leaning is 7 degrees to the west and 1 degree to the south. In the second storey the maximum leaning is 6 degrees to the west and 2 degrees to the north. In the third storey the maximum leaning is 1 degree to the west. The floor joists remain mostly horizontal.

The pillars are square in section and 30 cm wide, 1.8 m long and all of them are carved. For comparison, the central pillars of Kastha Mandap tower (which collapsed during last earthquake) are 36 cm wide and 6.2 m long. We can therefore say that the later pillars of Aganchen Temple are considerably wide. They are not made of a single piece of timber, but rather of 4 square timbers put together. Their measurements are taken in feet, so we can infer that they were introduced in the Rana period. We cannot know if there were any pillars below Aganchen Temple during the Malla period, but we can assume that the later pillars we see today are an addition after the 1934 earthquake.

From the outside, there is no significant damage in the first storey of Aganchen Temple. A check with a laser level revealed that the body of the tower retains its horizontality and verticality (Fig.

3-24). The podium made of brick masonry that supports the body of the tower seems to be built on top of the floor joists, and it has sunk 6 cm at the south end of the east front side. The reason of this sinking is not clear; therefore we would like the condition of the terrain around Hanumandhoka Gate, which is neighboring to the south. The necessary emergency repair will have to give consideration to the structure of the foundation of Aganchen Temple. Here, we can point out that currently the body of the three-storey tower is stable.

However, as we discussed before the later pillars located below Aganchen Temple are significantly inclined, and the outer west wall (the southwest wall of the west wing of Mohan Chok) is heavily damaged, especially around the wall openings. A 15 cm gap has appeared between the lower level of Aganchen Temple and the southern wing of Mohan Chok at the level of the floor under the roof structure (4th storey) (Fig. 3-25). This means that the lower level of Aganchen Temple has experienced a significant horizontal displacement towards the square side to the west. Thus, there is no structural continuity between the west and south wings of Mohan Chok. The horizontal purlins of the 3rd storey are actually cut at the inside of the southwest corner (Fig. 3-26). In addition, the floor height is different at the lower level of Aganchen Temple and at the west and south wings. Thus, it seems that the lower level of Aganchen Temple was structurally independent already before the earthquake. This is the result of the renovation works carried out during the Rana period at the original Malla period buildings. Mohan Chok and Sundari Chok (the building neighboring to the south) were further altered afterwards. Together with further surveys of the inside of the tower, a survey of several features will be necessary in order to clarify the history of alterations and renovations of these buildings. Such features include, for example, the gap between the independent first-storey columns of the courtyard and the doors on the wall, and the gap between the depth of the eaves and the rainfall drainage ditch at the courtyard.

Fig.3-22 Outer west wall below Aganchen Temple

Fig.3-23 First storey below Aganchen Temple

Fig.3-24 Aganchen Temple, first storey, east side (the green laser beams show the horizontal and vertical directions)

Fig.3-25 Gap between Aganchen Temple and the south wing of Mohan Chok (roof structure to the left, Aganchen Temple to the right)

Fig.3-26 Traces on the purlins of Mohan Chok (3rd storey staircase, the white chalk marks show the section of the purlin that was cut off)

3.7. Closing remarks

This was a preparatory survey of Aganchen Temple. Several issues were identified in relation to the provision of technical support for an actual repair plan. This tower is currently stable, but the outer west wall of the area below the tower is leaning towards Durbar Square, and the connection with the west wing of Mohan Chok as well as the areas around the openings are damaged. Although the outer wall has been shored as an emergency measure, the probability that this wall collapses in an aftershock, causing the complete collapse of Aganchen Temple, is extremely high. Therefore, among the buildings of Kathmandu royal palace, Aganchen Temple is at the same time an especially significant building from the historical point of view and a building in urgent need of repair, and requires our highest attention as an architectural heritage.

Through repairs, restorations and reconstructions, according to the needs of each royal dynasty, an invaluable ensemble of buildings has been preserved in Kathmandu Valley. Newar building techniques carry an ancestral knowledge. The authors would like to further clarify the building techniques hidden behind the loose timber frames and the fragile masonry walls. We believe that Japanese technicians, who are familiar with the highly developed and precise Japanese timber architecture, have much to contribute to the recovery of the architectural heritage in Nepal. It is our desire that we can learn from the study of the damaged buildings and contribute to hand the architectural heritage down to the next generation.

(Sections 6 and 7 author: Takayuki Kurotsu)

4. Structural Survey of Damaged Buildings

4. Structural Survey of Damaged Buildings

4.1. Survey purpose and overview

The devastation following the Gorkha Earthquake in Nepal was characterized to some extent in prior surveys. Referring to information obtained in these prior surveys, this structural survey focused on identifying earthquake weaknesses in Nepal's traditional buildings, which are mainly mixed structures comprised of brick and timber. Both observation and technical analysis techniques were used. A typical case of traditional building devastation was selected for detailed survey.

Select buildings were measured and scaled drawings were created. Details regarding the point and extent of devastation and the stability and materials (brick and timber) of the building structure were carefully recorded. Sampling tests of the building materials and vibration measurement were also performed. Results from this survey contributed to preservation planning and repair.

The survey period, primary activities, and participating investigators were as follows:

- Survey periods: 24–31 November 2015 3D and micro-tremor measurements
  24–28 December 2015 Building and material survey
- Investigators: Koshihara Laboratory, Institute of Industrial Science, the University of Tokyo
  Takiyama Laboratory, Tokyo Metropolitan University
  Miyamoto Laboratory, Kagawa University

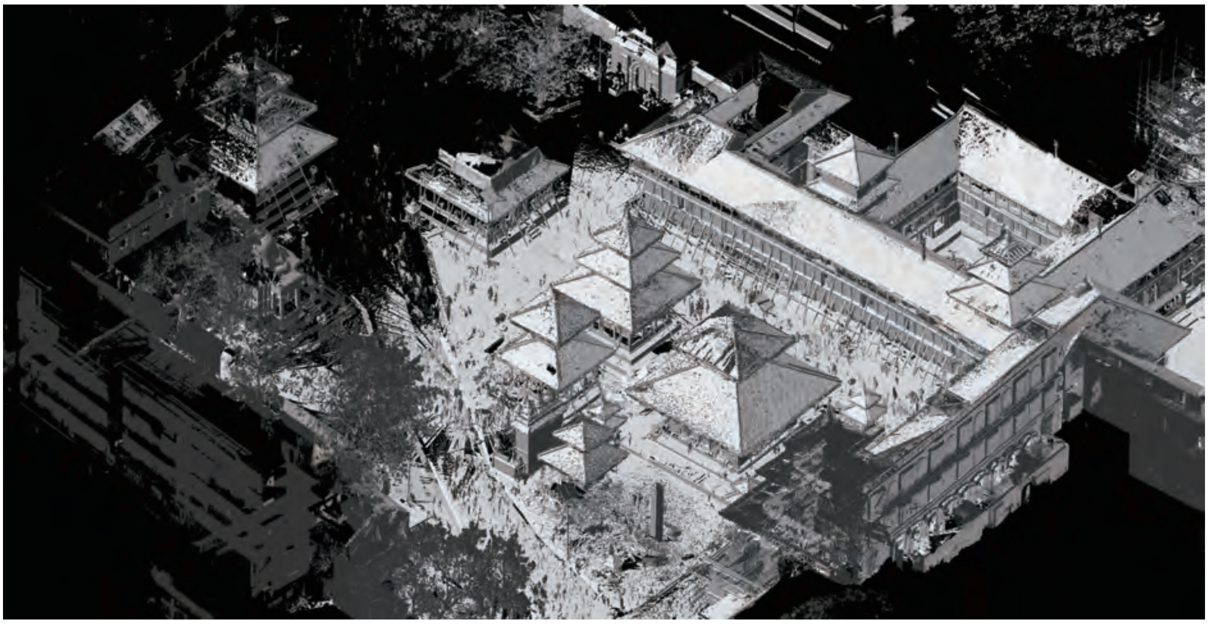


Fig.4-1 Shows the selected area for 3D measurement depicted using actual survey results

4.2. Detail building survey

The pagoda architectural style is common in Nepal's temples. Thus, a detailed survey was conducted for the pagoda features of the Jagannath and Gopinath Temples. Both experienced representative damage during the Gorkha Earthquake.

4.2.1. Jagannath Temple

For the Jagannath Temple, structural drawings that included each floor's framing plan and elevation, an X-Y cross section, brick details, and more were created from the detailed survey. The basic dimensions of the building and section were also recorded.

Brickwork formed the exterior and interior periphery walls of the first floor. As shown in Fig. 4-2, the brick measured 250 mm in width, 160 mm in depth, and 60 mm in height (glazed) in the outside wall, and 225 mm in width, 110 mm in depth, and 60 mm in height (unglazed) in the inside wall.

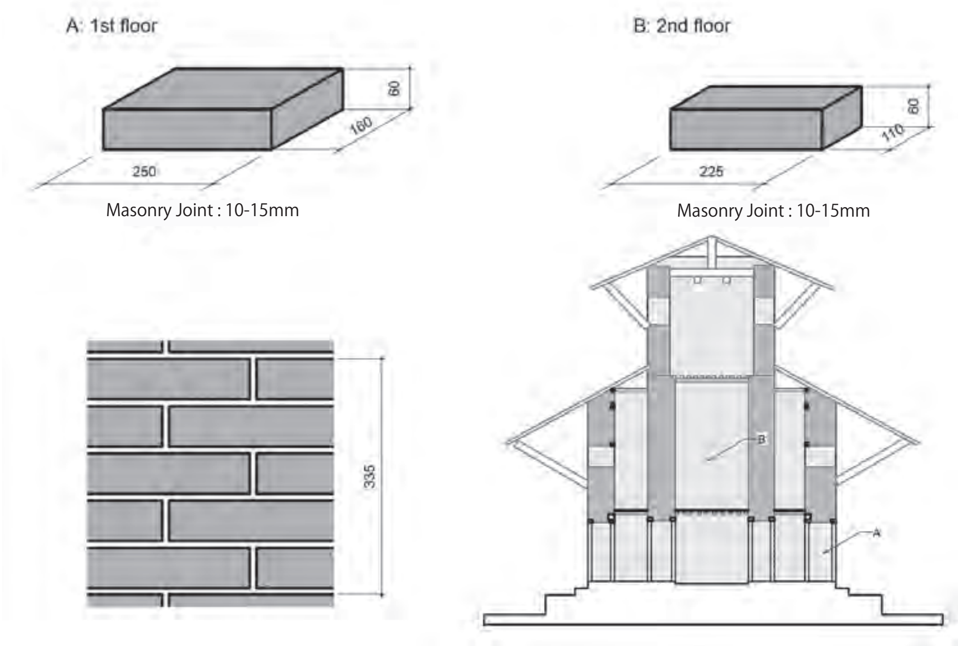


Fig.4-2 Brick size and location in the Jagannath Temple

4.2.2. Gopinath Temple

For the Gopinath Temple, as in the Jagannath Temple, structural drawings that included each floor's framing plan and elevation, an X-Y cross section, brick detail, and more were created from the detail survey. The basic dimensions of the building and section were also recorded.

Similar to the Jagannath Temple, brickwork formed the exterior and interior periphery walls of the Gopinath Temple's first floor. As shown in Fig. 4-3, the brick measured 210 mm in width, 115 mm in depth, and 55 mm in height (glazed and wedge-shaped) in the outside wall, and 225 mm in width, 110 mm in depth, and 60 mm in height (unglazed) in the inside wall. The roof truss on the top floor is a timber structure, and the roof beams span the brick walls.

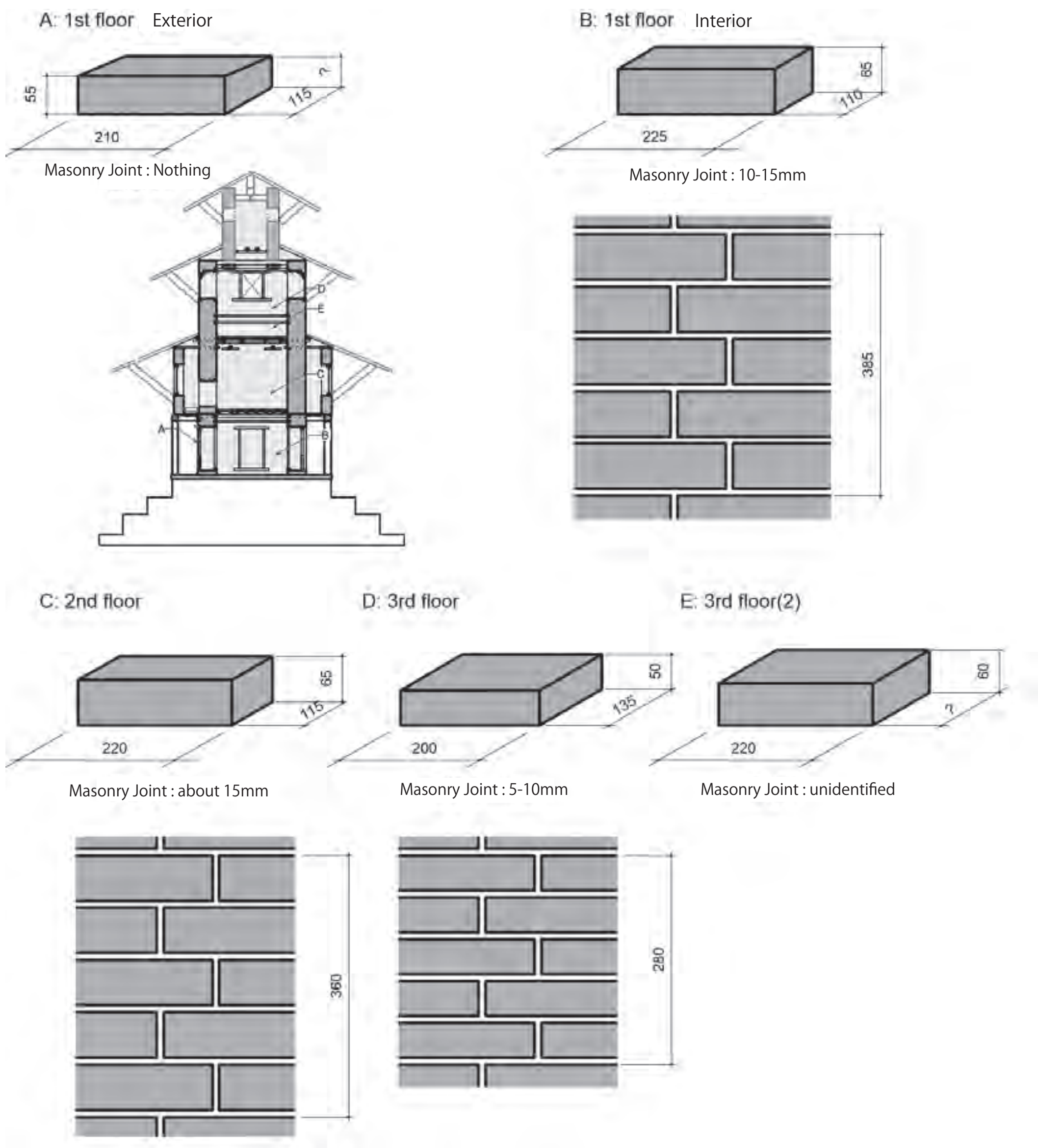


Fig.4-3 Brick size and location in the Gopinath Temple

4.3. Earthquake damage

4.3.1. General pagoda structures

The pagoda structures in the Jagannath and Gopinath Temples were constructed using brick walls and timber frames. When considering a building's ability to resist its own weight, three letter classifications are used: (A) buildings primarily constructed with brick walls, (B) buildings primarily constructed with timber frames, and (C) buildings whose timber frames are built on brick walls. Among these classifications, type C buildings suffer fewer total building collapses because the timber frames resist their own weight despite collapse and loss of structural function of the brick walls. As shown in Fig. 4-4, the mixed structural system characteristics of the pagoda structures in Nepal likely contribute to their superior seismic performance.

Fig.4-4 Changu Narayan Temple structure saved from collapse by the timber column

4.3.2. Jagannath Temple

As shown in Fig. 4-5 damage to the Jagannath Temple following the Gorkha Earthquake was concentrated in the third (top) floor of the building. The shear failure of the brick walls appeared at the cut-out for the roof beam. The shear failure was concentrated in the joint between bricks; failure of the brick itself was not observed.

Third (top) floor: Brick wall damage

Third (top) floor: Crack at roof beam cut-out (1)

Third (top) floor: Crack at roof beam cut-out (2)

Second floor: Slight inside and outside wall damage

Second floor: Slight inside wall damage

First floor: Slight damage

First floor: Slight damage

Adjunct tower: Heavy damage

Fig.4-5 Earthquake damage to Jagannath Temple

4.3.3. Gopinath Temple

Prior to the Gorkha Earthquake, the Gopinath Temple was reinforced with a temporary column and knee brace as an emergency measure against the earthquake damage. The knee brace provided additional support at the east and south sides of the structure; residual deformation to the east or southeast direction was likely. As shown in Fig. 4-6, structural damage to the Gopinath Temple was concentrated in the first floor. Primary structural damage included collapsed brick wall joints, peeled inner wall plaster, and fallen timber beams at the periphery. Conversely, wall damage in the second and third floor was not observed.

Third floor: Slight periphery wall damage

Second floor: Slight inner-periphery wall damage

First floor: Inner periphery wall peering plaster and joint damage

First floor: Periphery wall joint damage

Fallen timber beam

Fig.4-6 Earthquake damage to Gopinath Temple

4.4. Micro-tremor measurement

Micro-tremors were measured to identify the natural frequency and vibration mode of each subject building. Multiple measurements were taken: one on free ground, one on the podium, and several inside the buildings. The measurement point on free ground was at the front of the building. The measurement point on the podium was intended to detect any vibration amplification by the podium structure. Measurement points inside the buildings were at the top of the wall, on the beam, and on each floor close to a structural wall. The measurements were obtained using a portable vibration monitoring system (SPC-51) and servo-velocity meters (VSE-15D) produced by Tokyo-Sokushin.

Portable vibration monitoring system (SPC-51)

Servo-velocity meters (VSE-15D)

Fig.4-7 Equipments for micro-tremor measurement

4.4.1. Jagannath Temple

As a representative measurement result, Fig. 4-8 shows the transfer function in the east-west (E-W) direction for the Jagannath Temple. The transfer function was obtained by dividing the Fourier spectrum of building vibration monitored inside the building by the Fourier spectrum of ground vibration. The peak frequencies of the transfer function—2.6 Hz, 4.5 Hz, and 8.5 Hz—were estimated to be first, second, and third natural frequencies of the building.

Fig. 4-9 shows the vibration mode of elevation corresponding to the first, second, and third natural frequencies in the E-W direction for the Jagannath Temple. The vibration mode was obtained from the transfer function and phase information. At the first vibration mode, the third floor amplitude was larger than the first or second floor amplitudes. At the second and third vibration modes, each wall line had different vibration direction suggesting that the rigidity of the horizontal plane was not sufficient.

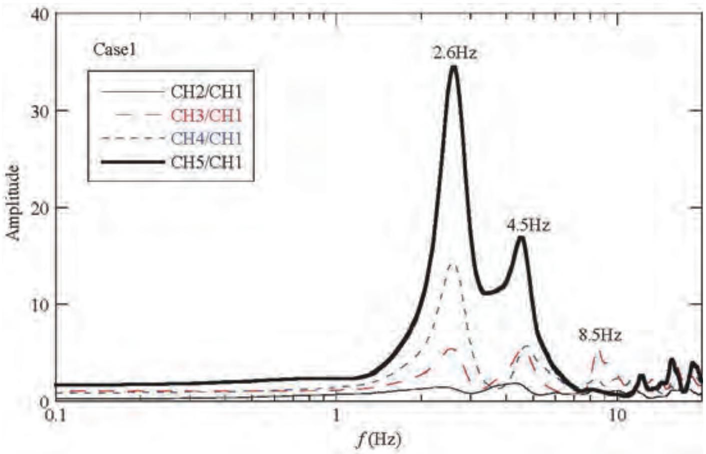
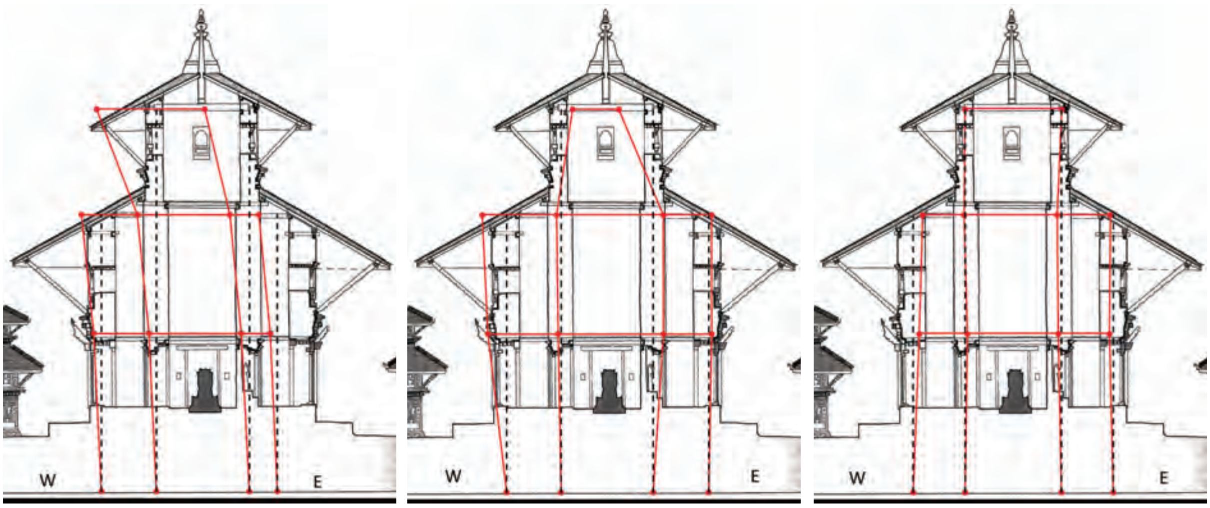


Fig.4-8 Representative Fourier amplitude ratio for the Jagannath Temple (E-W direction)



First vibration mode　Second vibration mode　Third vibration mode

Fig.4-9 Representative vibration mode for the Jagannath Temple (E-W direction)

4.4.2. Gopinath Temple

As a second representative measurement result, Fig. 4-10 shows the transfer function in the E-W direction for the Gopinath Temple. Again, the peak frequencies of the transfer function—2.0 Hz, 4.5 Hz, and 7.4 Hz—were estimated to be the first, second, and third natural frequencies of the building.

Fig. 4-11 shows the vibration mode of elevation corresponding to the first, second, and third natural frequencies in the E-W direction for the Gopinath Temple. Fig 4-7 reflects a simplified display that eases difficulty discerning the vibration modes of the inner periphery, periphery, and top floor. The roof shape was also removed to simplify the figure. The amplitude in the out-of-plane direction at the top of the inner periphery walls was large at the first vibration mode. At the second and third vibration modes, amplitudes in the north-south (N-S) direction were large.

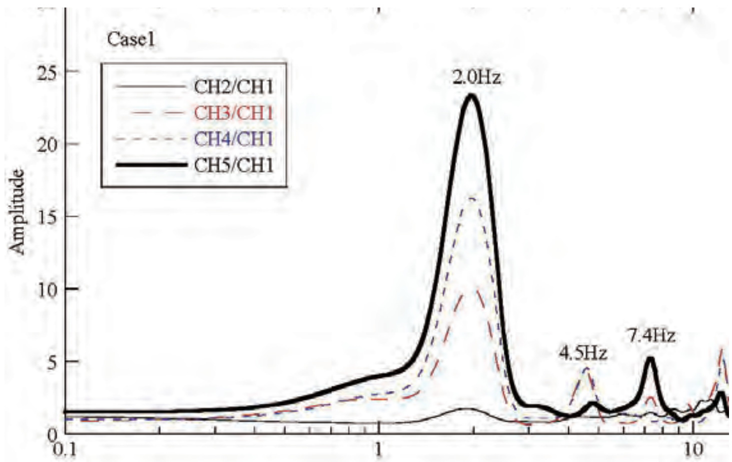
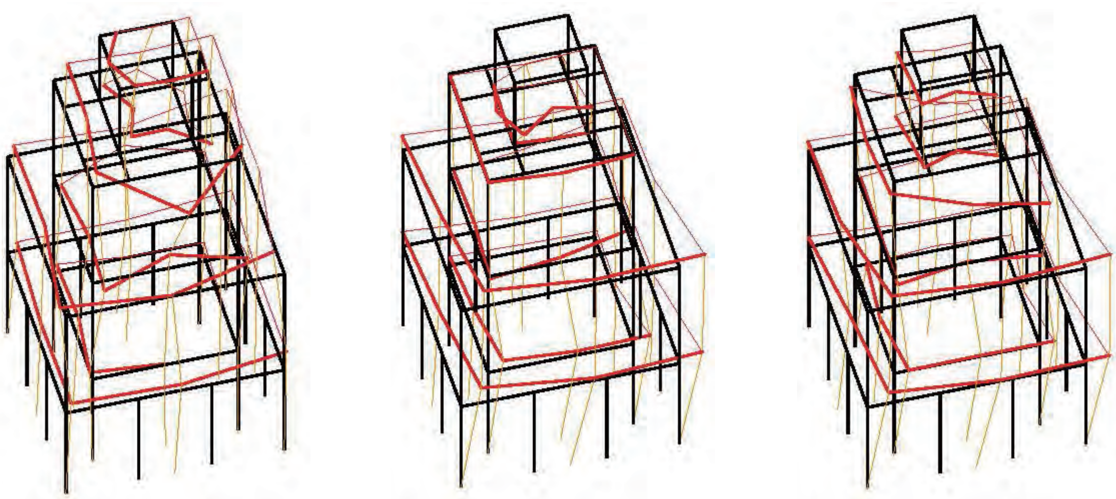


Fig.4-10 Representative Fourier amplitude ratio for the Gopinath temple (E-W direction)



First vibration mode

Second vibration mode

Third vibration mode

Fig.4-11 Representative vibration mode for the Gopinath Temple (E-W direction)

4.5. Structural analysis

4.5.1. Seismic performance evaluation

When evaluating the seismic performance of buildings, it is preferable to create a 3D analysis model using line, surface, and joint elements as shown in Fig. 4-12. These models can better adjust to the building conditions in Nepal that may include non-true vertical planes (e.g. a wall is not straight between upper and lower floors), insufficient rigidity in horizontal planes (e.g. floor and roof trusses are not sufficient), or unconfirmed rigid floor assumptions. This analysis considered performance against input earthquake vibration in conjunction with the previously developed mass point model that considers building weight and height, and previously reported performance results for brick structure (sufficient original data could not be collected within the scope of this survey). The analysis results were intended to support future reinforcement of Nepal's buildings.

When evaluating seismic performance, an initial parametric study was conducted to determine appropriate constants and accepted assumptions. The parameter values and assumptions used in this evaluation were as follows:

- Shear failure of brick itself is rarely observed, brick wall failure typically appears only at the brick joints.
- The shear strength of mortar joints, Fs, was set as 0.15 N/mm^2 or $0.0867 + 0.9\sigma c$ based on experimental results reported in 'Disaster Risk Management for the Historic City of Patan, Nepal' [Ritsumeikan University Institute of Disaster Mitigation for Urban Cultural Heritage (Rits-DMUCH) 2012, 83:Table 4.1].
- If mortar joints fail, the friction force between bricks is the primary resistance. The coefficient of static friction, μ, was set as 0.5.

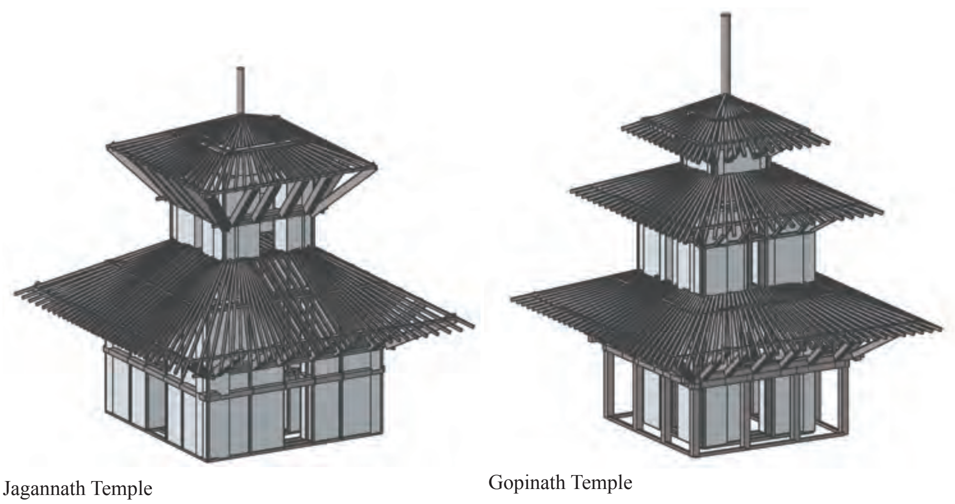


Fig.4-12 Example 3D analysis models

Table 4-1 lists additional parameters for various materials including adobe brick, mortar, and wood as reported in 'Disaster Risk Management for the Historic City of Patan, Nepal' (Rits-DMUCH 2012).

Tab.4-1 Estimated parameters for various material (Rits-DMUCH 2012)

Variable	Adobe Brick	Mortar	Wood
Mass density	1.8×10^3	-	7.0×10^2
Young's Modulus(N/m^2)	2.7×10^8	2.7×10^8	6.3×10^8
Poisson's ratio	0.11	0.25	0.3
Tensile strength(N/m^2)	-	0.0	1.1×10^8
Shear strength(N/m^2)	-	9.0×10^4	9.0×10^6
Friction angle φ	-	42.5°	0°
Compressive strength (N/m^2)	-	1.58×10^6	4.5×10^7

4.5.2. Jagannath Temple

Fig. 4-13 shows the weight of each mass point in the Jagannath Temple analysis model. Rooftop pinnacles, small openings, and wall thickness differences were ignored in the weight calculation. Table 4.2 lists the Ai distribution obtained from this weight calculation.

Assuming that the Ai distribution is equal to the acceleration distribution, an input acceleration of 0.25 G (C1 = 0.25) resulted in an output acceleration at the top floor of 0.482 G. Output acceleration may exceed 0.5 G if the external force is larger than the friction resistance between bricks at the top floor. This assumption corresponds with the field survey results for the Jagannath Temple that noted the earthquake damage concentrated at the top floor. A similar tendency is likely observed for buildings with upper floor walls that continue straight to the first floor.

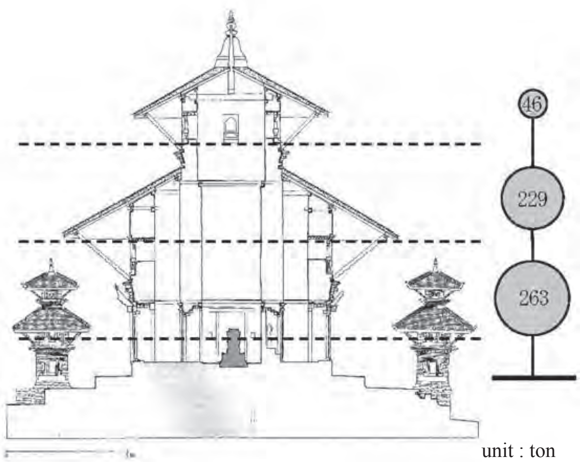


Fig.4-13 Mass point model weights for the Jagannath Temple

Tab.4-2 *Ai* distribution at each floor for the Jagannath Temple

floor	wi (kN)	Wi= Σ wi (kN)	αi Wi/W	Ai	Ci 0.1	0.25	0.5
3	454	454	0.086	1.928	0.193	0.482	0.964
2	2242	2696	0.511	1.248	0.125	0.312	0.624
1	2582	5278	1.000	1.000	0.100	0.250	0.500
0	727	6005					

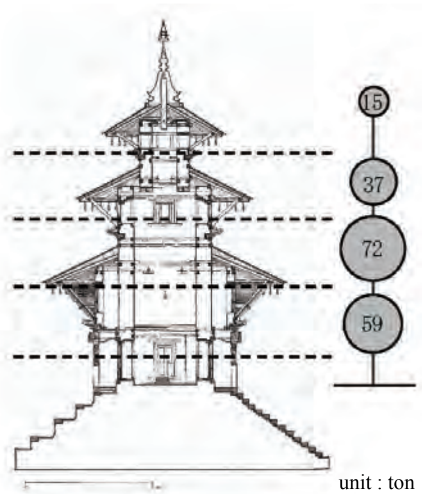
Building height, h = 12.0 m and first period, T = 0.24 s

4.5.3. Gopinath Temple

Fig. 4-14 shows the weight of each mass point in the Gopinath Temple analysis model. Again, rooftop pinnacles, small openings, and wall thickness differences were ignored in the weight calculation. Table 4.3 lists the Ai distribution obtained from this weight calculation.

Again assuming that the Ai distribution is equal to the acceleration distribution, an input acceleration of 0.25 G (C1 = 0.25) resulted in an output acceleration at the top floor of 0.472 G. Output acceleration may again exceed 0.5 G if the external force is larger than the friction resistance of the brick wall joints at the top floor.

This assumption corresponds with the field survey results for the Gopinath Temple that noted earthquake damage concentrated at the first floor. A similar tendency is likely observed for buildings with upper floor walls that do not continue straight to the first floor or with smaller cross-sectional brick wall areas at the lower floor compared with the upper floor cross-sectional areas.



unit : ton

Fig.4-14 Mass point model weights for the Gopinath Temple

Tab.4-3 *Ai* distribution at each floor for the Gopinath Temple

floor	wi (kN)	Wi= Σ wi (kN)	αi Wi/W	Ai	Ci 0.1	Ci 0.25	Ci 0.5
4	144	144	0.081	1.886	0.189	0.472	0.943
3	358	502	0.281	1.413	0.141	0.353	0.707
2	706	1208	0.677	1.139	0.114	0.285	0.569
1	577	1784	1.000	1.000	0.100	0.250	0.500
0	99	1884					

*Building height h; 10.5m, Design first period T; 0.21 [sec.] are assumed for calculation

4.6. Summary and conclusions

With regard to preservation planning and repair of Nepal's traditional buildings, it is important to consider the following findings obtained in this structural survey:

- Structural drawings and analysis models for subject buildings can be developed from survey results that describe building dimensions and construction methods. Structural analysis can be performed after verifying the material characteristics of brick, mortar, and timber.
- Micro-tremor measurement can be used to estimate the natural frequency and vibration mode of a subject building.
- Through approximate estimation of seismic performance, brick wall joints can be damaged by an input acceleration of 0.25 G and buildings incur concentrated damage either at the top or first floors.

- Some local engineers favour collapse mechanisms that allow reuse of bricks, viewing the removal of mortar and reuse of materials as a superior repair method. For preservation planning and repair, this requires prediction of the collapse mode of buildings and a method for valuing the building and its associated structural material.
- Bricks from a collapsed building are not always used to repair the original building. As such, reuse procedures must be coordinated among multiple projects.
- To prevent a more devastating collapse, joint failure should precede brick failure. Strength and compounding adjustments for joint mortar may be required. Adjustments should be made according to both preservation planning and structural performance considerations.
- Timber frames may prevent total building collapse following brick wall failure. Historical transition and usage methods must be coordinated.
- Careful documentation of building characteristics and construction methods is important before and after building collapse. In this survey, the brick and timber-frame systems inside the walls were difficult to comprehend without detailed information.

Based on this structural survey and the observations noted above, the seismic performance of the Jagannath and Gopinath Temples depends heavily on the performance of the mortar joints in the brick walls. To prevent a more devastating collapse from failure of the bricks, mortar performance should be designed to be lower than that of the brick itself to induce collapse from the joint. Further information is required regarding original timber elements; timber frames help to prevent total building collapse by resisting their own weight.

Most important for preservation planning and repair is to set realistic performance requirements (i.e. an acceptable degree of damage from an earthquake) and to regulate the building collapse mode to the extent possible. Future preservation planning and repair efforts can benefit from development of a detailed structural analysis model that includes accurate material characteristics. Preliminary assimilation of a material characteristics database using previously reported results for brick, mortar joints (existing and fresh), and timber elements (existing and fresh) is required.

(Chapter authors: Mikio Koshihara, Noriko Takiyama, Mitsuhiro Miyamoto, Hiromi Sato)

5. Survey on the Emergency Preservation Measures

5. Survey on the Emergency Preservation Measures

5.1. Survey purpose and overview

Following the Gorkha Earthquake, a large number of buildings in the World Heritage List collapsed in Hanumandhoka Durbar Square. Immediately after the earthquake, many people were trapped under collapsed buildings; fallen timber members were rapidly removed to facilitate rescue operations. The Hanumandhoka Royal Palace consists of several interconnected buildings with inner courtyards (Chok). Multi-tiered temples and other historic buildings stand closely together in the Durbar Square. Therefore, it is likely that different types of salvaged members from neighbouring buildings were gathered without being sorted. In many cases, only timber members with carved elements, such as window frames and struts, were set aside; long timbers without decoration were used to temporarily shore buildings that were still standing.

The Kathmandu Valley experiences periodic earthquakes, an earthquake of similar magnitude as the Gorkha Earthquake was last recorded in 1934. Thus, historic buildings in this region suffer repeated damage and sometimes collapse, but have been largely preserved until today through the reuse of the primary timber members. This method is also commonly used in Japanese historic buildings. One difference, however, is that Japanese buildings are constructed primarily of wood while Nepalese buildings are constructed using a mix of timber and brick materials. In Japan, structural stability is achieved through a frame with tightly joined wood members. In Nepal, the connections between wood and brick members are treated similarly; the entire structure is stabilized by filling gaps with brick. A second noted difference is that flexible woods (e.g. cedar, cypress) are used in Japan, while hardwoods (e.g. sal) are used in Nepal. Consequently, damage to timber members following collapse is minimal, facilitating the reuse of members.

Wood-brick connections require a certain allowance. These allowances support the use of timber members in different locations within the same building or in different buildings. In past repairs, timber members were often reused without regard to their original position. Members without decoration were often reshaped and long members (e.g. rafters) were repurposed as temporary shores. In buildings that contained timber members embedded inside the wall, wooden members were often removed during repairs, changing the building’s structural system. While these practices may still be considered traditional historic building preservation methods in Nepal, adequate damage survey and documentation guidelines must be established according to Venice Charter and Nara Document standards to ensure a level of authenticity consistent with World Heritage Site designation and to promote international understanding.

Although it was previously noted that timber members from different buildings are often mixed during rescue and repair, this was not the case for the members of the collapsed Shiva Temple on the east side of Hanumandhoka. Consequently, this building was selected as the subject of the emergency preservation measures survey. For this building, timber members were surveyed, classified and sorted, and properly stored according to their importance as part of the Kathmandu Valley World Heritage Site. Through these activities including transfer of Japan’s preservation survey method and the technical knowledge for cultural properties, we aimed to develop a method suited to the local conditions.

5.2. Emergency preservation measures for Shiva Temple

5.2.1. Description of Shiva Temple

Reportedly built in the 17th Century, the Shiva Temple is located east of Mul Chok in the Hanumandhoka Royal Palace. It is a relatively small, two-storey structure; the first storey is made of stone with free-standing pillars. During the Gorkha Earthquake, the building completely collapsed, falling into an ablution fountain to the south. During the November 2015 survey, timber members form this building were assembled in an open lot to the north. Because Shiva Temple stood independently without any other proximate buildings and was located inside the Palace area where public access is restricted, it is one of the few buildings in Hanumandhoka with readily associated timber members.

Furthermore, the building is close to HDMDC (the institution that manages the Hanumandhoka Royal Palace) temporary office. Thus, it was possible to secure space to sort and store the salvaged members, and to work in close coordination with HDMDC. The proximity of Shiva Temple to HDMDC directly supported this project's efforts to transfer technical knowledge and further confirmed selection of this building as a suitable subject for the emergency preservation measures survey.

5.2.2. Classification of salvaged members

The emergency preservation measures survey was conducted in two stages during November 2015 and March 2016. Timber members had been gathered without regard for their position and use before the collapse. Therefore, activities performed in November 2015 focused on gaining a general understanding of the original member locations, and sorting and classifying the easier to identify carved members.

Japanese experts and Nepalese workers from HDMDC worked cooperatively in this effort. Beginning from the top of the member pile, carved elements were removed and temporarily placed in the open lot according to the type of member. Complex elements comprising several members, such as

Fig.5-1 Foundation of collapsed Shiva Temple

Fig.5-2 Shiva Temple before Gorkha earthquake, Photo by MDC

window frames, were collocated and temporarily assembled. Elements were also classified according to carving motifs.

To support the establishment of guidelines that allow data sharing among the surveyed buildings in the Kathmandu Valley World Heritage Site, a model investigation sheet was designed. Several characteristic members from the Shiva Temple were measured and recorded using this model sheet; Nepalese staffs can follow these examples when documenting other building members. Members from the Shiva Temple were also photographed and a separate document depicting their layout was prepared.

To support the transfer of technical knowledge, an on-site workshop was held. Staff from HDMDC and UNESCO asked questions and opinions were exchanged. These meetings also provided an opportunity to distribute the model survey sheets to these agencies.

The second stage of the emergency preservation measures survey was conducted in March 2016. Long timber members from the main frame and eaves were sorted and classified. Again, Japanese experts and Nepalese workers participated cooperatively in these efforts. Old bricks that were scattered on the site were also sorted.

In addition to classifying members according to their type (as was done in the first stage), second stage activities included attaching identification cards to each of the members. These identification cards are intended to be used regularly in future repairs. Currently, Nepalese staff use identification cards made of plastic tape when classifying carved members. Considering requirements for durability and weather resistance, 6 × 4.5 cm veneer cards—similar to those used for the conservation of cultural properties in Japan—were prepared. The card format and content were designed to be simple and widely applicable, including only a building number (according to assigned building numbers on the UNESCO map of World Heritage monuments in Durbar Square), a storey number, a member number, and a consecutive category number given the total number of category members. A table summarizing the member identification information was prepared separately.

Identification cards were nailed to known members, such as pillars and beams. In addition, each member’s position inside the storage facility (described in Section 5.2.3.) was recorded. Members with indeterminable original positions, such as connecting members laid inside the brick wall or roof structure members, were classified by type and stored without identification cards in preparation for future surveys.

Fig.5-3 Classification of the caved members

Fig.5-4 On-site workshop

Fig.5-5 Classification members according to their type

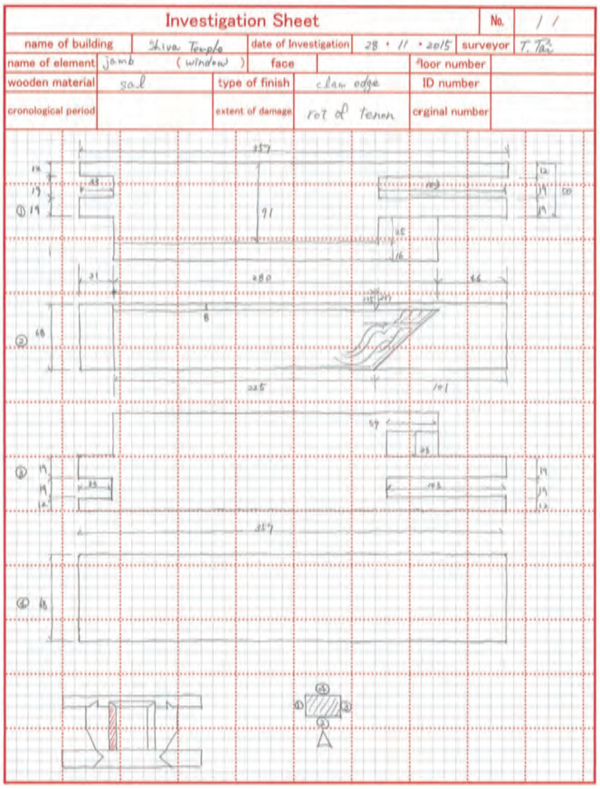


Fig.5-6 Example of the investigation sheet

Fig.5-7 Example of the identification card

Fig.5-8 Sorting of the structural members

Fig.5-9 Storage of the structural members

5.2.3. Construction and use of the storage facilities

Immediately after the Gorkha Earthquake, timber members from collapsed buildings at Hanumandhoka were haphazardly gathered. Members were directly laid on the ground or on porch floors and covered with vinyl sheets without any cushioning between members.

Because these members may have to be stored for relatively long, a temporary storage facility was built to prevent further member damage or decay and to provide easy access to the members if future surveys are required.

The storage facility was designed to be versatile and built from local materials. It comprised three levels of shelving made from steel pipes fixed with clamps and a single-flow roof made from corrugated steel sheets. After storing the members, the storage facility sides were covered with vinyl sheeting.

Considering the volume of timber members to be stored, a 4 × 2 m facility was built on the southeast corner of the lot to store the carved members identified in the first stage. In the second stage, 6 × 2 m and 4 × 2 m facilities were built on the west side of the lot. The layout and scale of the facilities built in the second stage was adjusted to allow for construction of a new on-site miniature museum.

The storage facilities were designed to allow all members stored at the same time to be stored at the same location. Each member's location inside the storage facility was recorded, and wood pieces were inserted between members to protect them.

5.3. Summary and conclusions

Although the time to conduct the emergency preservation measures survey was limited, nearly all members were considered, and valuable information was gained regarding building renovation in Hanumandhoka Durbar Square.

The Shiva Temple had been recently repaired, with particular changes to the outside members of the top storey. Most members in the eaves had also been renovated. Simple square timbers were used for struts in place of carved timbers, and the repairs were of a temporary nature. The first-storey structure included carved wooden pillars around the outer brick wall and timber frame around the inner brick wall. Many of these wooden members were heavily decayed at the bottom. It can therefore be assumed that at the time of the previous repair, the structural system had already been altered; the top storey was only being supported by the brick wall. Members that remained unseen were not always removed or replaced at the time of repair. Consequently, a sufficient survey of the members could reveal the original building structure and assembly even after renovation.

In addition, chisel marks found on some of the members can serve as an indicator for assembly although it was not clear if these marks are original. The chisel marks observed in this survey were scattered and did not always match. However, the chisel marks indicate required member modifications based on their specific position inside a building.

Although this survey contributed significantly to the understanding of emergency preservation measures in Nepal, establishing guidelines to ensure authenticity in Nepal's historic building preservation requires careful documentation and information sharing not only for a single building but for all buildings in Hanumandhoka Durbar Square.

(Chapter author: Tadatsugu Tai)

Fig.5-10 Storage condition of the caved members

Fig.5-11 Storage condition of the structural members

Fig.5-12 Constructed Storage facilities

Fig.5-13 Chisel mark

Fig.5-14 Wooden pillars around the inner brick wall of the first-story

Fig.5-15 Wooden frame assumed to be a roof truss

6. Survey of Historic Settlements

6. Survey of Historic Settlements

6.1. Outline of Khokana village

In the Kathmandu Valley, seven heritage sites, including three royal palaces and four religious sites, were registered as Nepal's first World Heritage sites in 1979[1] (Fig. 6-1). A further four sites in the valley are included on the tentative list. These mainly include people's dwellings that developed around the royal palace in Kathmandu Valley towns that evolved around trade routes as well as towns where clusters of medieval architecture remain (hereafter referred to as "medieval settlement landscape"). These sites would expand the registration of heritage sites that have an historical relationship to the Kathmandu Valley World Heritage site[2].

Cultural Heritage preservation in Nepal is managed by the DoA under the Ministry of Culture, Tourism and Civil Aviation, under the Ancient Monument Preservation Act, 2013. However, the historical settlements registered in the tentative list are not included under the same. 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[3].

This section summarizes the investigations at Khokana village, one of the four villages registered in the tentative list, from the viewpoint of understanding the village as a cultural heritage and the damage caused by the earthquake.

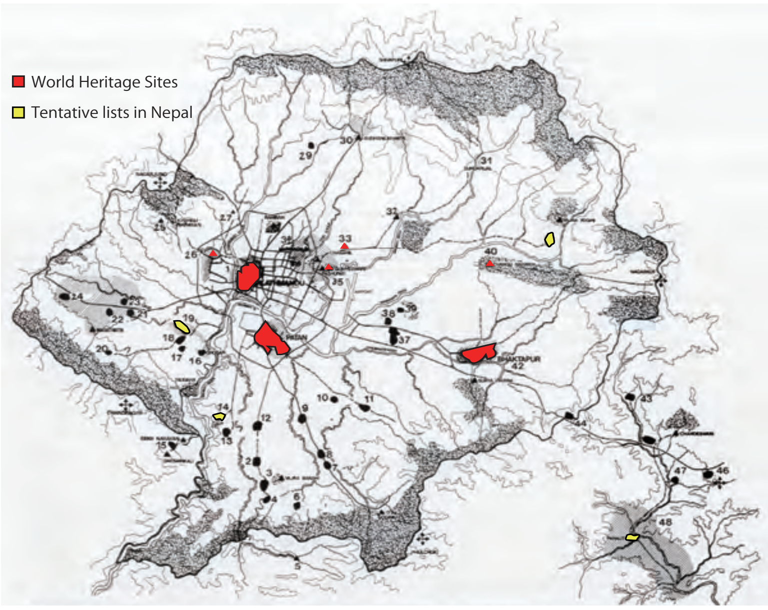


Fig.6-1 Cultural properties on the list of World Heritage sites and tentative list, quoted from *"Newar Towns and Buildings"* and retouched by the author. Khokana village is located in No.14)

1 http://whc.unesco.org/en/statesparties/np (accessed 2016-02-03)
2 http://whc.unesco.org/en/tentativelists/5258/ (accessed 2016-02-03)
3 "Conservation Guidelines for Post-2015 Earthquake Rehabilitation" currently being prepared by UNESCO Office in Kathmandu Domestic Consultant Kai Weise. However, during the 5 February 2016 seminar we have learned through the delegate of the DoA and the UNESCO Office in Kathmandu that these guidlines have not yet been made the official guidelines of the Nepal government.

The Gorkha Earthquake left 9 dead and 28 wounded (Source: note 4) and caused extensive damage to traditional buildings. After the earthquake, the Khokana Reconstruction and Rehabilitation Committee was formed, and it has promoted self-governing recovery efforts such as removing rubble and cleaning up, dismantling crumbled buildings, and writing reports[4] that may serve as the preparatory stages of a future recovery plan. In November 2015, public spaces such as roads and squares were being cleaned, and some crumbling buildings were being dismantled. In contrast, the removal of rubble and reconstruction work hardly progressed in settlement areas.

6.2. Spatial analysis and total survey of building damage

6.2.1. Survey aim

Urban Design Lab,The University of Tokyo, conducted a spatial analysis in Khokana to understand it as a cultural heritage. Furthermore, a total survey of buildings along the street was conducted to understand the disaster from the viewpoint of preserving the cultural landscape of the historical settlement. These surveys were conducted to subsequently suggest a rehabilitation plan centering on the conservation of the village.

6.2.2. Spatial analysis of Khokana

Khokana village is known as a place for producing mustard oil. The village is located along a trade route between India and Tibet, and in a city that was established by merging five Village Development Committees (VDCs) last year. The former Khokana VDC roughly overlaps the territory of the historical Khokana village, and its boundaries are fundamentally water boundaries (Fig. 6-2). The settlement of the village is divided into the two areas: north and south. The former wards no 1–8 are called the Southern Settlement Area, and ward no.9 is called the Northern Settlement Area. The population of each is 5,132 and 236, respectively. Most Khokana residents are farmers. The two settlement regions are in hillocks, and the topography gently inclines towards the Bagmati River. Here, there are terraced paddy fields that are irrigated using the Rajkulo (King's canal); they form a beautiful landscape. According to the survey report published in 1977 by UNESCO et al., these terraced paddy fields are called an "Amphitheatre," and they are considered important elements in Kathmandu Valley cultural tourism. Moreover, the fields provide spaces for festivals and funerary ceremonies as well as for agricultural activities. The routes from the two settlement areas, through the terraced paddy fields, to the Shikali Temple on the western edge and the crematory on the Bagmati riverside, are decided depending on whether it is a festival or a funeral. There are some places of worship and stone sculptures along the route, providing it with some religious meaning. Shree Rudrayani Temple is located in the center of the Southern Settlement Region. It has so-

4 We got Khokana proposal 3rd draft from Nabin Dangol 2015-10-02

called Newar architecture, and it is a three-story temple. It 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 (Khwelacchi Chok) down towards the west. The Nyala Dan Street (hereafter called the main street) running east to west is the central axis joining these two spots (Rudrayani Temple and Kwoe Lachhi Chowk). There are comparatively many traditional Newar-style dwellings nearby that, together with the Rudrayani Temple, leave behind the visage of the medieval period. Near the entrance of the village, there are two mustard oil factories that are said to have been established as guard points.

Fig.6-2 The territory of Khokana (Retouched on Bing map by the author)

6.2.3. Exhaustive survey of building damage

(1) Survey method

By referring to past research[5] and hearings conducted with specialists[6], buildings were classified as traditional construction (brickwork with a wooden frame) and nontraditional construction (RC Build: C Type). Traditional constructions were further divided into those having no extension work (A Type) and those having extension work (B Type)[7]. With regard to the Damage condition, we established three stages: Heavy, Moderate and Slight. This survey uses visual observations to judge the disaster damage to façades, and an exhaustive survey of buildings along the street was conducted from the perspective of townscape preservation[8].

5 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

6 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)

7 UNESCO: Heritage homeowner's preservation manual, 2006

8 EMS98 (G.Grunthai (Editor)): European Macroseismic Scale 1998, 1998

The survey was conducted from November 22 to December 6, 2015, by seven members: Takeshi Kurose and Tomoko Mori from Urban Design Lab, the University of Tokyo; Sakura Kawata and Taiga Sunazuka, students in the Master's degree program; Professor Bijaya Shrestha of Khwopa Engineering College, who is a graduate of the University of Tokyo; and two of Prof. Shreshta's students. Based on teams made up of one person from Tokyo University and two people from Khwopa Engineering College, each building was assigned a number, its façade was photographed; and measurements were performed with a focus on the number of floors, number of added floors, existence of partitioning, use of ground floor, wall thickness, and frontage and ceiling height. Furthermore, the extent of damage was judged based on the above-described building classification.

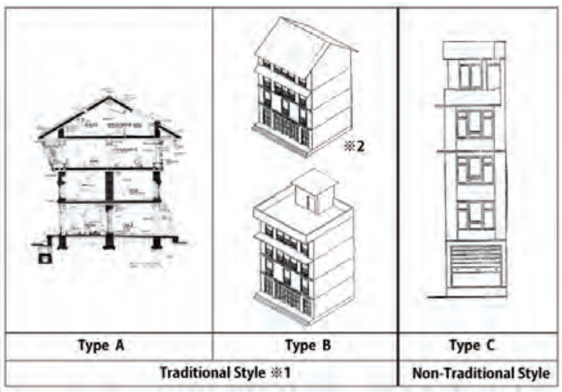


Fig.6-3 three types of construction(pictures were quoted from foot note 5)

*if it is difficult to judge the type, it will be Type AB
*even if there are added floor, buildings in good condition will be Type A

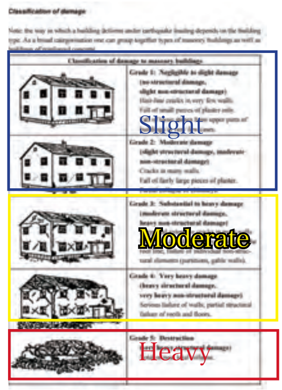


Fig.6-4 Three stages of damage (Quoted from foot note 6)

(2) Survey results

From the survey results, records were taken for 596 buildings. This section presents an overview of the analysis of 577 buildings in the southern settlement area.

1. Building Ratio by construction method

We found that ~60% of the buildings were made using traditional construction methods.

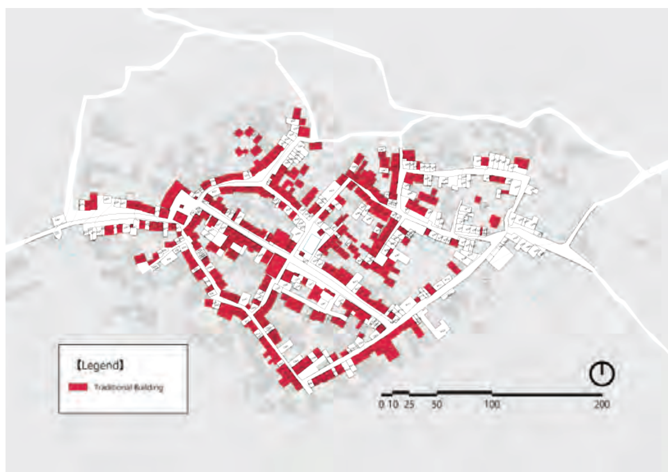


Fig.6-5 Distribution diagram of traditional buildings in South area

2. Damage condition

Approximately 15% of the traditionally constructed buildings were completely destroyed; ~47%, partially destroyed; and ~40%, slightly damaged or undamaged (Figs. 6-6, 7). Through hearings, we also found that there were cracks inside the buildings and curving in the floors; this damage needs to be addressed in the future. It is assumed that these results will not match those of the structural judgment, because this is survey strictly concentrates on Damage condition pertaining to the external appearance of buildings.

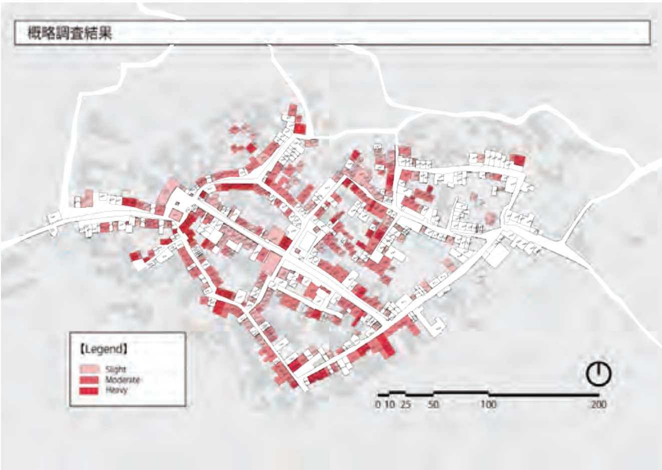


Fig.6-6 Damage level of traditional buildings in the south area

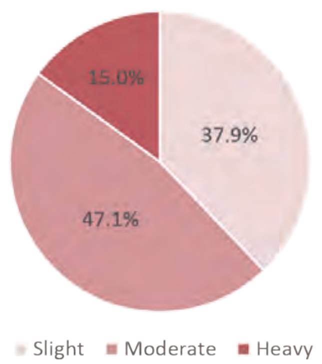


Fig.6-7 Damage level of traditional Buildings in the south area

3. Issues related to damage to traditionally constructed buildings

In addition to the issue of the reconstruction method to be used for 52 completely destroyed buildings, the issues of whether existing repair reinforcement construction is possible for 163 traditionally constructed buildings (Fig. 6-8) that have been partially destroyed and the necessity of a concrete presentation of methods also need to be considered. The residents of these partially destroyed buildings dismantled the collapsed ceilings and covered them with zinc-coated steel (Fig. 6-9), and they continued with plumbing work to use their houses as a toilet and storage space during the day and slept at temporary residences at night. To preserve the village house rows, there is an urgent need to establish a repair reinforcement method for partially destroyed traditionally constructed buildings.

Fig.6-8 Location of the traditional buildings that have suffered moderate level damage in the south area

Fig.6-9 Examples of traditional buildings that have suffered moderate level damage

6.2.4. Issues and considerations for nontraditionally constructed buildings

Nontraditionally constructed buildings included many five-story buildings made mainly of reinforced concrete as the main structural part, with brick masonry on the exterior walls. Such buildings were equally distributed in the region, raising concerns that they could seriously damage the landscape. This study focused on the materials and finishing used on the surface of these buildings and their floor height on both sides of the neighborhood making up the façade of Nyala Dan street, the main east–west running street, and the following analysis was conducted to understand the aim of apprehending the current situation.

(1) Materials and finishing

On both sides of the neighborhood that makes up the main street, we classified the materials and finishing that make up the façade and conducted analyses after calculating the distribution area. In façade A (northern side), although 11 out of 15 buildings (~70%) were traditionally constructed buildings, half the surface area of the façade was replaced with modern materials (Fig. 6-10). Furthermore, a trend was observed in that the ground floor and entire surface was finished with mortar for repairing exterior walls; another trend observed was that nontraditionally constructed buildings were finished with vivid colors.

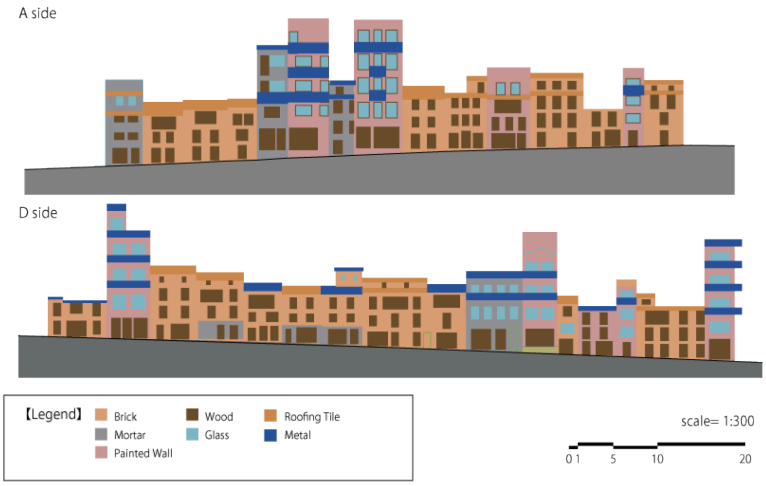


Fig.6-10 Classification of the material and finishing of façade of Main Street

(2) Neighborhood cross section

From the analysis of the ground floor ceiling height ascertained through the survey, we found that whereas the average ceiling height for traditionally constructed buildings was ~1,900 mm, and that for nontraditionally constructed buildings was 2,500 mm.

Furthermore, on the main street, we created and analyzed separate cross-sectional figures for traditionally constructed buildings (cross section A) and nontraditionally constructed buildings (cross section B) (Fig. 6-11). The difference in the floor heights and number of floors in traditionally and nontraditionally constructed buildings is clearly changing the landscape of the neighborhood. In many buildings, the floor height of the ground floor was increased, and concrete stairs were constructed to eliminate this gap, thus changing the landscape of the ground level. There was a tendency to use the ground floor as a garage for motorbikes, and in some cases, a slope had been made to the street (Fig. 6-12).

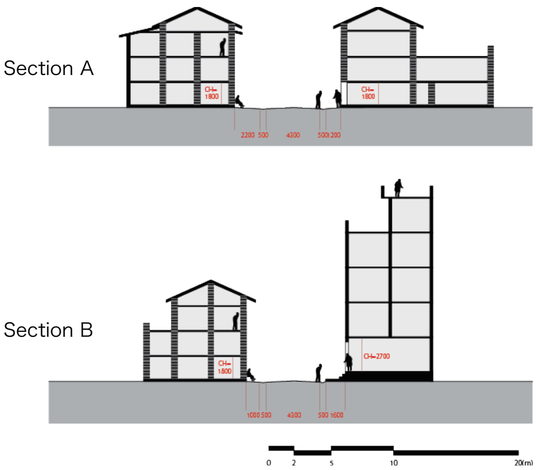


Fig.6-11 Schmatic section of the main street

Fig.6-12 Photo of Main street, Nov. 2011

6.2.5. Construction of temporary residences

More than 300 temporary structures have been constructed after the earthquake in the perimeter of Khokana village (Fig. 6-13). Many of these are built on vacant land having comparatively little inclination; this land was used for farming and related work around the village. Furthermore, part of the forest land surrounding the village is being used for temporary residences, and the forest cover is therefore decreasing. As a result, the clear division between the village and the terraced paddy fields is being lost, and the temporary residences are increasing 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, thus forming a ring road around the village.

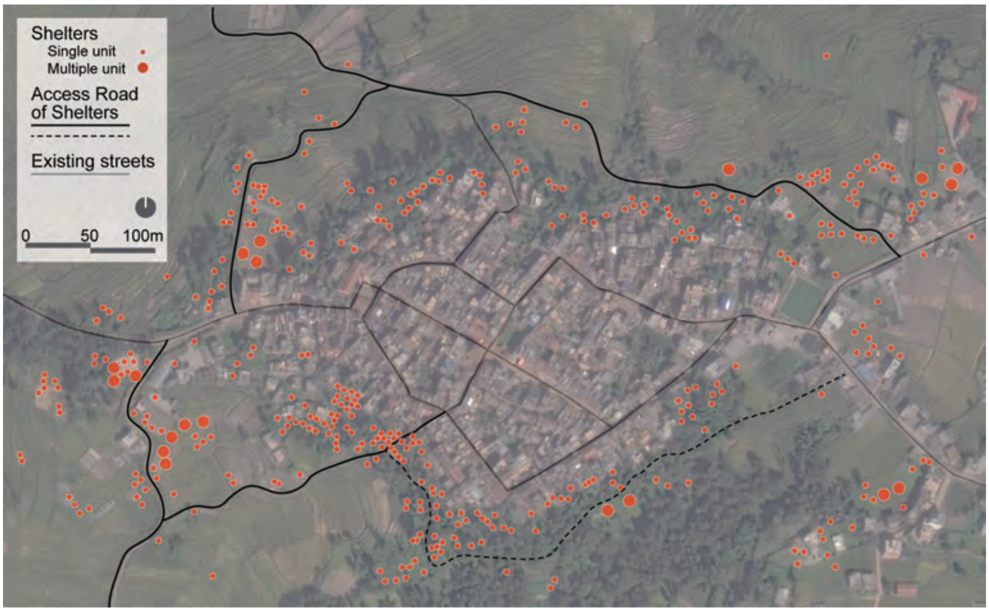


Fig.6-13 Aerial photo before earthquake(Quoted from Google Earth, taken on 25 Oct. 2014), location of Temporary Residences (shelters)

6.2.6. Summaries and considerations

First, from the spatial analysis of the village as one unit of the former Khokana VDC area, we recognized the terraced paddy fields that seem to have been established and developed based on the settlers' deep understanding of the topography and daily and nondaily life. The irrigated terraced paddy fields in the Kathmandu Valley have value as a cultural landscape. Therefore, further study must focus on clarifying the relationship between the Kathmandu Valley and the historical settlement.

Second, through an exhaustive survey of building damage by observing the disaster damage to façades from the perspective of neighborhood preservation, records were taken for 596 buildings.

We found that ~60% of buildings are made by traditional construction methods. Furthermore, ~15% of traditionally constructed buildings were totally destroyed, ~47% were partially destroyed, and ~40% were slightly damaged or undamaged. The reconstruction method to be used for 52 completely collapsed buildings as well as the repair and reinforcement construction methods to be used for 163 partially collapsed traditionally constructed buildings have not been presented. There is an urgent need to establish repair reinforcement methods for buildings from the viewpoint of preserving the village scapes. In the guidelines that the DoA is attempting to draw up, “Historical Settlements” will be defined for the first time. However, it is necessary to maintain the economic incentive for preserving buildings made by traditional construction methods and to perform reconstruction using traditional methods; this needs to be done before any other rehabilitation and reconstruction work that is conducted in the future.

On the other hand, the nontraditionally constructed buildings suffered relatively slight damage. However, ~40% of the buildings are made by nontraditional methods, and they are a part of the historical settlement. Therefore, it is necessary to draw design guidelines for the nontraditionally constructed buildings, because there are concerns about further changing the landscape of the neighborhood.

Finally, the farm roads outside the village are being extended as access roads to temporary houses in the perimeter of the village, thus forming a ring road around the village following temporal expansion of the settlements. The temporary houses may become permanent residential land, because regulations for land usage have not been established. Therefore, it is our opinion that it is necessary to establish some rules regarding the future development of the area surrounding the village.

(Sections 1 and 2 author: Tomoko Mori)

6.3. Survey of transformation of townscape

6.3.1. Summary of survey

First, we need to focus on the evolutionary process of the townscape of Khokana, from the spatial condition of reconstruction after the disaster of 1934, the townscape of 1996 when Khokana was evaluated as a candidate World Heritage site, to the current townscape. We should collect information about the original housing units and their lots and determine the causes of the spatial transformations. We examined previous studies and related documents and conducted field surveys, including interviews and measurements. From December 2 - 6, 2015, we interviewed residents of Nyala Dan street about the changes in the uses of houses and courtyards, family compositions, and so on with the help of an interpreter and determined the transformation along the Nyala Dan street over time and analyzed the factors contributing to the same.

As a result, we identified the following causes of changes. The increase in population, changes in family structures, and division of extended families into individual households (nuclear family, etc.) has influenced the division of existing houses/properties or extension/renovation of houses. Furthermore, changes in lifestyle have led to residents extending their living spaces, especially the kitchen, thus transforming the townscape. Further, changes in the spatial use of agricultural facilities (workshops, sheds for cattle), for example, for drying cereals, have led to changes in their interior spaces or façades.

We have also studied the relationship between the transformation of the townscape and the damage situation as well as the damage in the rooms, and we have presented these results.

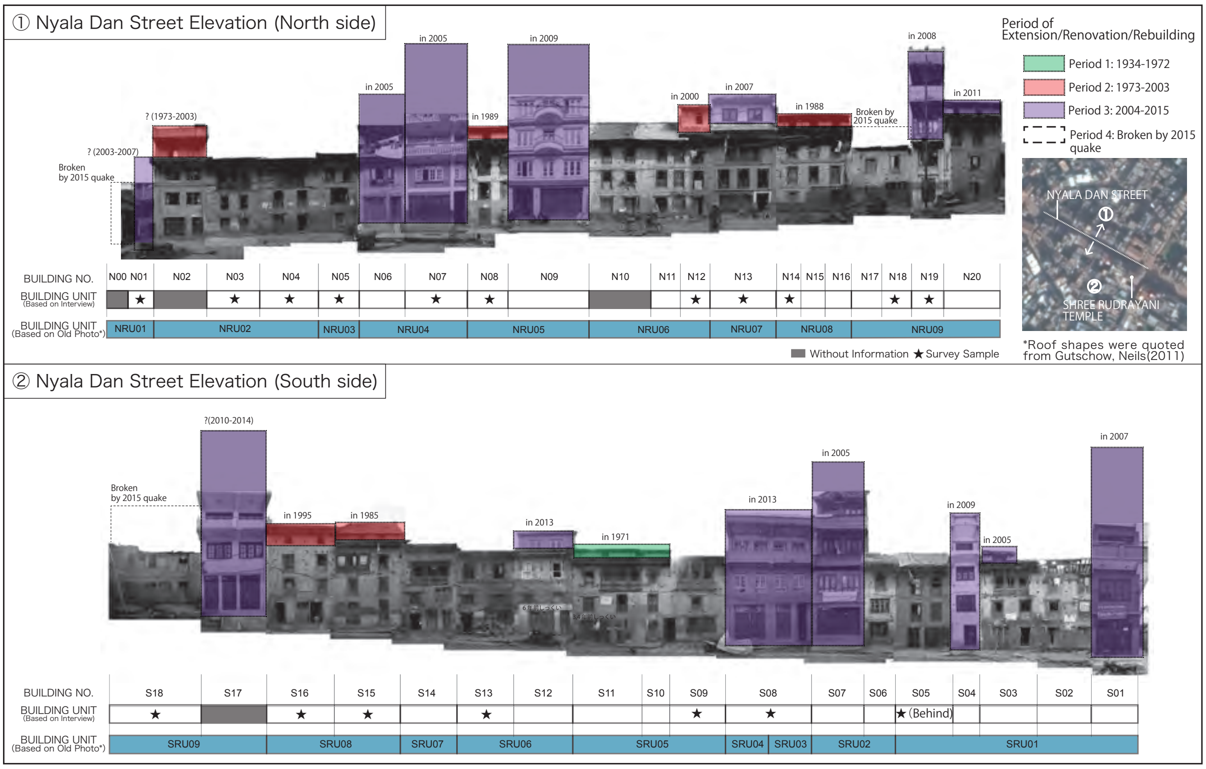


Fig.6-14 Transformation along Nyala Dan street (Chronicle of the Extension/Renovation/Rebuilding identified by inteviewing)

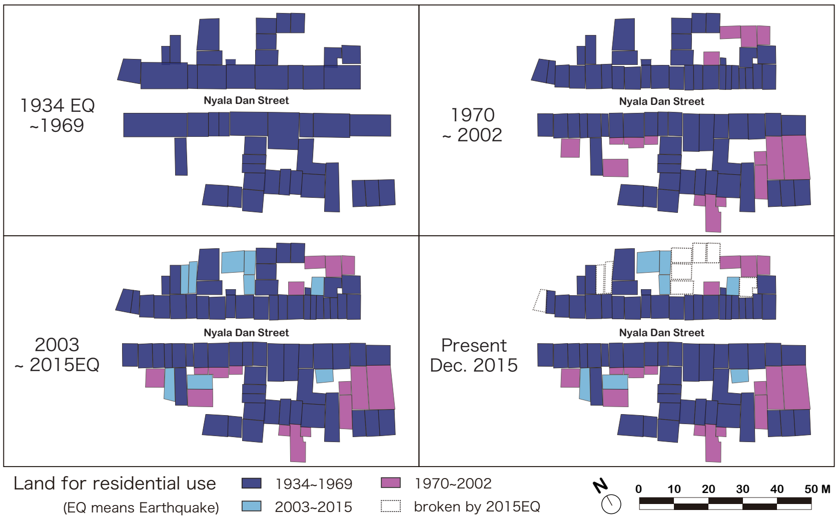


Fig.6-15 The evolutionary process of the lands for residential use from the earthquake in 1934 to Gorkha earthquake in 2015

6.3.2. Recommendation from the viewpoint of study of townscape and transformation and future developments

In addition to the results presented in the other volume, we would like to make the following three recommendations based on our results:

(1) Design guideline that reflects the demands of residents in living spaces
(2) Transformation in structure of village (e.g., past land use, housing layout)
(3) Study on new residential areas corresponding to the increase in population

The following should be studied in the future (details are presented in a separate volume)

(1) Survey of lifestyle with relatives based on their occupation

It is necessary to develop a rehabilitation plan for collapsed or damaged houses in Khokana to maintain the local community. In addition, it is advisable to rehabilitate the village while preserving and continuing the current residents' lifestyle as much as possible, in terms of aspects such as neighboring relatives, sharing kitchens, and having meals together, which we found in this investigation. With regard to constructing a new residential area, the local community still needs to participate in the planning in consideration of each resident's occupation and the relation of residential area to farm land. To plan the residential area in a manner appropriate to the residents' lifestyle, we need to conduct a more detailed investigation of the residents' occupations and lifestyles.

(2) Detailed investigation of traditional houses in Khokana

One of the four traditional houses that escaped collapse by the earthquake in 1934 is situated along Nyala Dan street. This house has undergone many transformations, in a manner similar to other houses. However, the piled up stones from before 1934 remain in the foundation, as do engraved members inside, and the original courtyards are kept in good condition. There is also an altar with a deity, and this house is thus a public space for residents. As it is a very important house in the history of Khokana, it is advisable to investigate it in greater detail from the viewpoint of its conservation/restoration.

Fig.6-16 Traditional house constructed before earthquake in 1934 still remain, although the additions have been made

Fig.6-17 Carved pillar that was reused as a beam

(3) Making mechanisms for both rehabilitation of historic townscape and preserving beautiful terraced paddy fields

Most of the terraced paddy fields in Khokana are the properties of local farmers. They are directly related to the rehabilitation of the townscape (funds for restoration and rebuilding of houses). Consequently, one of the most important issues is to manage the necessary farm land for the protection of the townscape of the entire village of Khokana. If famers sell the farm land or lease it to people living outside Khokana to raise funds for reconstructing their houses, it will worsen the townscape, pollute the water, and possibly break-up the community. Therefore, there is an urgent need to provide funds to both rehabilitate the townscape and protect the terraced paddy fields.

(Section authors: Hiroki Yamada and Naoaki Furukawa)

6.4. Survey of Intangible cultural heritage

6.4.1. Summary of survey of cultural space in Khokana

The constituent elements of the traditional neighborhood of Khokana include not just its buildings but also spaces such as streets, plazas, and religious sites such as small temples as well as the daily life elements around wells and other areas. In many cases, these elements are intimately related to the intangible cultural heritage, such as faith and daily life.

The preservation of these cultural spaces is indispensable to restoring Khokana while preserving its traditional neighborhood. We conducted a survey of elements related to these cultural spaces (small shrine (Lacchi/Chaitya), Pagoda, Buddhist temple, rest space (Pati), square, well, pond, water area, mustard oil mill, others).

We identified a certain number of element types and mapped their distribution as “the inventory of the elements of the cultural space in Khokana”.

6.4.2. Survey of water landscape in Khokana

Through the survey of the cultural space in Khokana, we discovered the importance of water-related elements in Khokana. One point requiring attention for the future restoration of the neighborhood is that reconstruction should be carried out without drastically changing the makeup of this cultural space. In particular, the six ponds play an important role in rituals; on the other hand, water pollution is a serious problem. Water pollution is also a serious problem for traditional water resources such as wells in squares.

We think that the traditional waterscape of Khokana was constructed logically. However, today, this system faces the serious problem of water pollution and is on the verge of a crisis. We think that there are two measures for solving this problem. One is to improve the water drawn into the village through a canal by establishing a water purification plant immediately before it reaches Khokana. The other is to develop sewers. In this way, by working to improve the water quality, the pond water will become cleaner, and the aesthetic value of Khokana as a cultural heritage site will improve. We think that this will also improve the residents' quality of life by allowing them to use well water more safely.

Site 1
種類：ため池
現地名：Kha Pukhu
地理的位置：北緯 27 度 38 分 09.76 秒　東経 085 度 18 分 01.44 秒　標高 1327m
概要：コカナの 6 つの主要なため池のひとつである。調査時には水はたまっていたが、ゴミなどが投棄されているのが認められた。

Fig.6-18 Example from the inventory of the Khokana cultural spaces

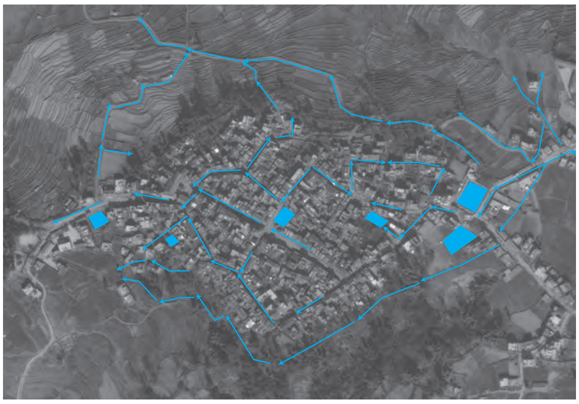


Fig.6-19 Traditional drainage system inside and periphery of Khokana

6.4.3. Considerations from study of intangible cultural heritage

Through this survey, we learned that not only the traditional neighborhood but also the elements of the cultural space play an important role in Khokana's value as a cultural heritage site. To recover Khokana village, we think that developing these elements of the cultural space while preserving them will guarantee their value as cultural heritage. Obviously, in addition to the cultural spaces, the rituals and other elements of the intangible cultural heritage play an important role. However, these issues need to be better understood through future study.

(Section author: Tomo Ishimura)

6.5. Structural analysis on traditional buildings

In addition to an exhaustive survey on the damage of buildings in Khokana, a structural analysis of the damage to both traditional buildings and RC buildings was conducted. The definitions of the types of structures and the degree of damage are the same as those used in the study by Tokyo University (Figs. 6-3, 4). Examples of results are shown in Figs. 6-20–6-23. Furthermore, the damage was also analyzed based on the façade drawing before the earthquake and microtremor measurements. The details of this survey are presented in the other volume.

(Section author: Mitsuhiro Miyamoto)

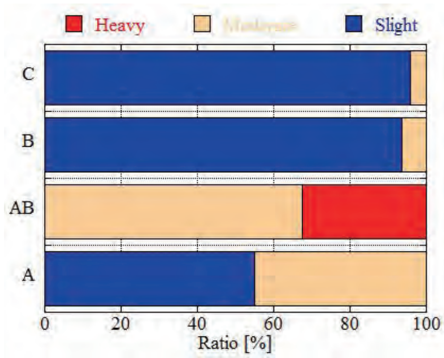


Fig.6-20 Relation between the type of building structure and degree of damage

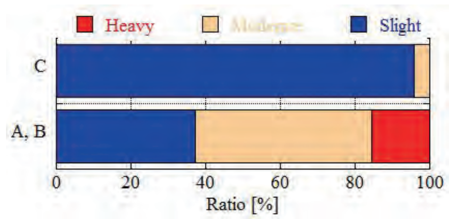


Fig.6-21 Relation between the type of building structure and degree of damage

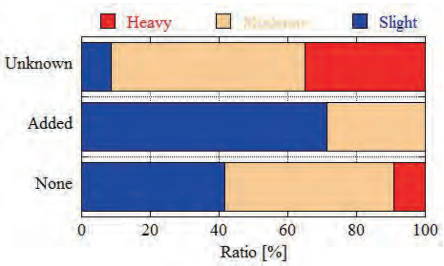


Fig.6-22 Relation between the presence or absence of extension and degree of damage

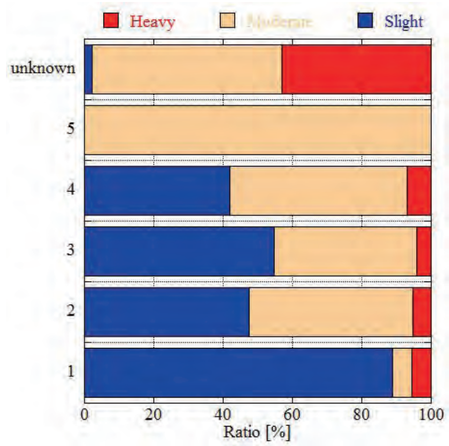


Fig.6-23 Relation between the number of building story and degree of damage

6.6. Survey of residents' intentions after earthquake: Rebuilding of houses

6.6.1. Overview of survey

After the Gorkha Earthquake, a survey was conducted to understand residents' intentions regarding the rebuilding of houses. This survey aimed to identify problems and tendencies regarding rebuilding and to estimate their influences on changes in the townscape.

The survey methods were to investigate the appearances of buildings and to conduct interviews.

From the appearances, (1) construction and (2) damage suffered were investigated. Additionally, interviews were conducted as necessary to complement the information obtained through observations.

In the interviews, interviewers asked the respondents for their (1) name, (2) age and gender, (3) family structure, (4) uses of each floor before the earthquake, (5) state of residence after the earthquake, (6) type of land ownership, (7) ways of rebuilding (sites, funds, and methods), (8) program of rebuilding, (9) problems in rebuilding, (10) problems before the earthquake, and (11) other matters. Furthermore, photographs were taken of the informants themselves and the state of damage of their houses.

The interviews were conducted from August 10–19, 2015, and from December 25, 2015, to January 1, 2016. The surveys were conducted in four areas—Chorcha and Suryamadhi in Bhaktapur, Chyasal in Patan, and Khokana—and 34 people participated in the interviews. In this section, residents' intentions regarding rebuilding and their changes are studied, especially in Khokana.

6.6.2. Summary of result

The investigations showed that many people hoped to cooperate in the design of the townscape and to rebuild their houses with the Newar style exterior design. These are the results of the Khokana reconstruction and rehabilitation committee's efforts to reconcile differences in local opinions. At the same time, they show that the committee is expected to raise funds. Some residents had a realistic opinion that it was difficult to raise funds to unify the exterior designs of all houses, and they emphasized their personal rights by calmly judging the committee's strong opinions and activities.

Major problems such as how to raise funds, how to solve land ownership problems, and the methods by which to rebuild houses remain, even though immediate reconstruction and improvement of townscapes are needed. The investigations revealed many efforts to reconstruct and change the intentions of rebuilding, and residents' opinions or forward-thinking about their way of life in Khokana were not heard clearly.

During the reconstruction of the townscape of Khokana, we should not concentrate on only regulating the façade design. Instead, we should also focus on and share the importance of the way of life of Newar that has been established in Khokana. Then, arguments regarding the design of each house and that of the townscape can be made through an appropriate process.

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").

(Section author: Yasushi Takeuchi)

7. Survey on Intangible Cultural Heritage

7. Survey on Intangible Cultural Heritage

7.1. Survey purpose and overview

Nepal is a multi-ethnic country, and each ethnic group has rich intangible cultural heritages. Rites and festivals, in particular, deeply connect ethnic groups, castes, and local communities. Investigating Nepal's rites and festivals following the Gorkha Earthquake was important; following the Great East Japan Earthquake, rites and festivals were considered to be strong motivators for recovery from the earthquake damage.

Fully understanding Nepal's intangible heritage was difficult because no prior inventory had been made. According to Mr Jaya Ram Shrestha, Head of the Department of Antiquities, Nepal had ratified the UNESCO's Convention for the Safeguarding of the Intangible Cultural Heritage in 2010, and had only recently implemented a protection policy. Development of an inventory is underway; the '*Dhami-Jhakri* of Tharu people' (customary dancing with drums) is anticipated as the first registered inventory entry in 2017.

In this survey of intangible cultural heritage, earthquake impacts to the *Indra Jatra* festival in Kathmandu (the largest festival in Nepal) and the *Machhendranath* festival in Patan were investigated. It was difficult to investigate earthquake impacts to the long-duration *Indra Jatra* festival in advance because the schedule of festival events [except the *Kumari* (shrine maiden) tour] was unknown. The festival is based on religious faith and its schedule is determined through fortune tellers. Although this festival is as large as the *Gion* festival in Japan, the *Indra Jatra* festival does not encourage tourism and participation by 'non-believers' is limited. Nepal's intangible cultural heritage is generally different from Japan's cultural heritage that is separated from religion and strongly encourages tourism.

Nevertheless, many of Nepal's historical buildings will likely be utilized as tourist attractions, with associated revenues providing a fiscal resource. Similarly, intangible heritage features, such as the *Indra Jatra* festival, may one day serve as a tourist attractions. Although this report is not advocating this festival's tourism potential, it is important to investigate intangible cultural heritage from a protection and use point of view with this future application in mind.

7.2. *Indra Jatra* festival in Kathmandu

7.2.1. Setting-up-the-pole event

The *Indra Jatra* festival is held for eight days that span the occurrence of the full moon in September. The festival includes many events; the first of which is the setting-up-the-pole event held outside of the Jaganath Temple in Hanumandhoka. Timber used for pole is cut in Nala (east of Bhaktapur) and brought to Kathmandu using only human power. Similar to the *Onbashira* festival in Japan, the act of falling a sacred tree is itself part of the event. The pole arrived in Hanumandhoka on 21 September 2015. When the Japanese survey staff arrived in Hanumandhoka on 22 September 2015, the Nepalese people bowed to the laid pole (Fig. 7-1).

The first official day of the *Indra Jatra* festival and the day for the setting up the pole was 25 September 2015. Although the published start time was 10 AM, fortune tellers directed activities to begin at 7 AM. Thus, the main *Indra* pole was already set before survey staff arrived; staff were able to observe the setting of small secondary poles around the *Indra* pole (Fig. 7-2). Bamboo material was attached horizontally to the secondary poles and subsequent approach of the *Indra* pole was prohibited. Next, a small *Indra* statue was placed at the foot of the pole, with offerings of food and money.

At a different festival location, a storehouse in Hanumandhoka was opened for exposition of a large *Bhairab* mask (*Seto Bhairab*) (Fig. 7-3). In Durbar Square, a wooden tower was built in front of the Shiva Temple (which collapsed during the Gorkha Earthquake), and a *Bhairab* statue was placed inside it (Fig. 7-4). In Indra Chok (northwest of Hanumandhoka), large towers for the *Indra* and *Bhairab* statues were built facing each other (Figs. 7-6 and 7). The *Bhairab* statue was not placed before noon on 25 September 2015 as is customary; instead, it was placed on 27 September 2015 with a beautiful flower adornment.

In front of the Kathta Mandap, in the southwest corner of Durbar Square, a high tower for an *Indra* statue was built (Fig. 7-5). The tower, which was not yet constructed on the morning of 25 September 2015, was in place for tour of *Kumari* on 27 September 2015. In addition to the scientific aspects of the *Indra Jatra* festival, it is important to also research and document the festival's logistical aspects (i.e. management of statues and materials, temporal scheduling, venues, etc.). Although the *Indra Jatra* festival seemed to be minimally affected by the Gorkha Earthquake, it may have experienced longer-term effects from the urbanization of Kathmandu. Monitoring and documentation of longer-term impacts to the *Indra Jatra* festival may be required.

In one local custom to honour the recently deceased (held on 27 September 2015), bereaved family members walk around the statues by torchlight. It was assumed that victims of the Gorkha Earthquake were included in the deceased. Customs such as this demonstrate Nepal's overlapping relationship between memorial services and personal rites and large cultural heritage festivals.

According to the prior information, traditional groups come from Kathmandu and Bhaktapur to perform various rites around Hanumandhoka beginning on the evening of the first day of the *Indra Jatra* festival through the last day of the festival. The Japanese survey staff were unable to observe these events because their date, time, and place were not publicized.

Fig.7-1 Laid pole (22 September)

Fig.7-2 *Indra* pole

Fig.7-3 *Seto Bhairab* at Hanumandhoka

Fig.7-4 *Bhairab* statue at the Durbar Square

Fig.7-5 The *Indra* statue at Kastha Mandap

Fig.7-6 *Indra*

Fig.7-7 *Bhairab* at Indra Chowk

7.2.2. *Kumari* tour

The *Kumari* tour began on 27 September 2015—the third day of the *Indra Jatra* festival. The area around Durbar Square was crowded by noon, although the tour did not begin until 2 PM. Because a portion of the Square was blocked to ensure security of participating dignitaries, public spectators gathered on the stepped foundations of the Shiva and Narayan Temples. Both temples had collapsed during the Gorkha Earthquake; safety concerns prevented many people from gathering there before 2 PM.

The tour was led by a chariots occupied by a local Kumari girl as a living goddess and her attendants, *Bhairab* and *Ganesha,* played by local boys (Fig. 7-9). These chariots were first displayed between Kumari's house and Hanumandhoka on 25 September 2015. Each chariot had a traditional upper shape and chariot cabs were supported by iron frames with rudders. These vehicles seemed unaffected by the earthquake and did not seem to require traditional construction methods.

Around 2 PM, the dignitaries departed and the Durbar Square blockade was raised allowing public entry. Musicians began performing and *Bhairab* and his two attendants (*Sawabak*) (Fig. 7-10), *Mahakali* (Fig. 7-11), and *Purksi* (a white elephant) (Fig. 7-12) were observed in the Square.

At 2:40 PM, the chariots departed Kumari's house—*Bhairab* first, *Ganesha* second, and *Kumari* last—and travelled southwest through the Shiva and Narayan Temples. The chariot tours were conducted on the third, fourth (in the opposite direction), and eighth (final) days of the *Indra Jatra* festival.

The *Kumari* tour is a very popular festival event. Although conditions in Durbar Square changed significantly following the Gorkha Earthquake, festival participants remained excited to be there (Fig. 7-13). Other factors may be more influential regarding changes to the *Indra Jatra* festival. For example, the *Kumari* tradition requires the participating girl to be isolated, which by today's social norms is regarded as child abuse. Accommodating or modifying such traditions in the future will be challenging. Anticipated future festival changes suggest the need for careful documentation of traditional practices.

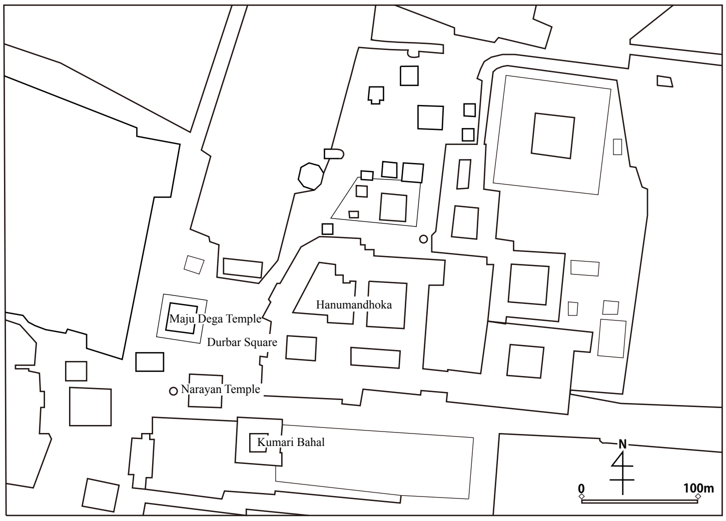


Fig.7-8 Map of Hanumandhoka Durbar Square

Fig.7-9 *Bhairab* chariot, *Ganesha* chariot, and *Kumari* chariot (from the left)

Fig.7-10 *Bhairab* and *Sawabak*

Fig.7-11 *Mahakali*

Fig.7-12 *Purksi*

Fig.7-13 *Kumari* tour

7.2.3. *Indra* festival in Khokana

Concurrent with the primary *Indra Jatra* festival in Kathmandu, secondary *Indra* festivals are held. Japanese survey staff attended one such festival— Yenya Punhi in Khokana. On 24 September 2015, the day before the setting-up-the-pole event in Kathmandu, a pole no taller than a person's height was set at the Kwelachhi Chok (Site 32) in Khokana. Statues of *Indra* and *Khun Dhyo* (a thief) were placed on it (Figs. 7-14 and 15). Worshipping the 'thief god' is associated with Indra's experience when he stole flowers for his mother and was caught.

Punhi means full moon; the festival is held for eight days that span the occurrence of the full moon in September. The festival meal or *samay baji*, which includes mashed dried rice or *chiura* and four additional dishes, is served in the village on the full moon. The smaller Yenya Punhi festival is managed by eight families in succession; each family stores the statues and other materials until the next families' turn.

The *Yenya Punhi* festival represents an important example of intangible cultural heritage in Khokana, but also—along with the *Indra Jatra* festival in Kathmandu—represents the broader regional full-moon *Indra* celebrations throughout the Kathmandu Valley. Consideration of the respective festivals will help to identify unique local characteristics and better understand local cultures.

Fig.7-14 *Yenya Punhi* setting-up-the-pole in Khokana

Fig.7-15 *Yenya Punhi* statue in Khokana

7.3. *Rato Machhendranath* festival in Patan

7.3.1. Chariot tour

As part of the annual *Rato Machhendranath* festival held in Patan, a chariot is drawn from Bungamati every 12 years (Fig. 7-16). This event is called *Bunga Dya* (or *Bunga Dya Jatra, Bunga Dya 12 Barsa Mera, Bara borse Jatra*). The year 2015 represented the twelfth year; the chariot had departed Bungamati in March 2015.

The *Bunga Dya* event was interrupted by the Gorkha Earthquake which occurred on 25 April 2015 between Bungamati and Khokana. It is likely that many people in Bungamati and Khokana avoided danger from collapsing buildings because they had gone outside to view the chariot. This event resumed during the conduct of this survey without any announcement; on-site Japanese experts were able to observe the drawing of the chariot.

Rato means red, indicating the colour of the statue. Although this festival is often regarded as a counterpart of the *Seto Machhendranath* (*seto* means white) festival in Kathmandu, the festival in Patan is thought to be older. The god worshipped at the Machhendranath Temple in Patan is the creator of the cosmos and controller of the rain for agricultural purposes (Fig. 7-17). Thus, the *Rato Machhendranath* festival is held in April and May before the rainy season. A statue is usually placed on the chariot on the day of the full moon in April. After touring Patan, the statue is carried to Bungamati on a portable shrine where it is displayed at the Machhendranath Temple (which collapsed during the Gorkha Earthquake) until September 2015. After September 2015, the statue returns to Patan. In this way, the *Rato Machhendranath* festival involves both Patan and Bungamati.

The chariot tour resumed on 22 September 2015 in front of the Purna Bakery (500 m north of Bungamati). The *Kumari* in Bungamati travelled to this location. Honour guards and musicians arrived at 3 PM and began playing music and dancing in front of the chariot. The chariot began to move at 4 PM,

Fig.7-16 *Machhendranath* chariot

Fig.7-17 Chariot statue

travelling north along the road connecting Bungamati and Patan (Ekantakuna Tika Bhairav). The chariot proceeded very slowly, moving just 100 m before stopping. It arrived north of a bus stop in Bhainsepati at 6 PM, advancing only 2 km in 2 hours.

The chariot tour procession included a water truck (with potable water for participants and spectators to drink), various honour guards and musicians, the drawers of the chariot, and a vast multitude of spectators. The road connecting Patan and Bungamati was completely blocked. Some spectators on a crowded riverbank were pushed by guards and fell into the river as the chariot approached while other spectators climbed on top of house roofs along the road to view the chariot causing some concerns for safety.

The chariot's crossing of the Nakhkhu River (a branch of the Bagmati River) began on 23 September 2015 as the climax of the Patan tour (Fig. 7-18). The chariot departed from the previous day's location at 4 PM and arrived at the river's edge at 5 PM after manoeuvring down a steep slope. Instead of using the constructed roadway bridge, the chariot navigated across a shallow section of the river. After approximately one hour, the chariot climbed up the bank with assistance from a power shovel. The chariot inclined precariously during its ascent, causing spectators to take refuge. The chariot travelled a total of 1.2 km, including the river crossing, and stopped at a bus stop in Nakhkhu overnight. The chariot would enter Patan the next day.

A smaller chariot of *Minnat* (daughter of Machhendranath) was waiting for the arrival of Machhendranath along a road in Patan (Fig. 7-19). Both chariots would subsequently travel together.

The crossing-river at the Nakhkhu river, a branch of the Bagmati river, began on 23 as one of the climax of the tour to Patan (Fig. 7-18). They left the roadstead of the previous day at 4 PM, and arrived at the river at around 5 PM after going down the steep slope. They went down to the riverbank without crossing a bridge on the road, and crossing the shallow made for this festival for one hour. After crossing the river, they climbed up the bank with assist of a power shovel. The chariot was inclined once during then, and spectators had to take refuge. They moved for 1.2 km on the day including the crossing-river, and stayed at a bus stop of Nakhkhu. They were finally going to enter Patan the next day.

A smaller chariot of *Minnat* (a daughter of *Machhendranath*) was waiting for the arrival of *Machhendranath* on a road in Patan (Fig. 7-19). They were going to go around together.

7.3.2. Chariot and festival logistics

Because new chariots are built each year in advance of the *Rato Machhendranath* festival, chariot craftspeople are assigned individual parts (e.g. wheels, woodwork) to complete. Roles during the tour are also assigned according to caste: Buddhists (*Shakya*) lead the rites, and peasants (*Maharjan)* draw the chariot and play music. The roles of local communities represented by *Guthi,* temples, administrations, and tribes should also be considered. Objective documentation of these respective roles would support response to anticipated long-term changes and encourage international understanding.

An interview with a former *Kumari* girl conducted by the National Geographic following the Gorkha Earthquake proved interesting, especially when talking about inadvertent changes to tradition.

According to her, the main chariot pole should have been made from a large tree, but was instead made from several smaller trees, chariot decorations were positioned incorrectly, important rites were omitted, and a number of roadside stops were skipped. As a religious event, such changes should be accepted if they have a religious rationality but this requires an understanding of the factors that motivated the changes. As a traditional event, careful documentation of the chariot's construction and festival operations can help to retain cultural heritage. Although bringing the viewpoint of the Japanese administration for cultural properties to foreign rites should be argued, demonstrating the importance of objective documentation is required, particularly when considering the rapid development of Kathmandu.

Fig.7-18 Nakhkhu river crossing

Fig.7-19 *Minnat*, Patan chariot

7.4. Summary and conclusions

This survey investigated the *Indra Jatra* and *Rato Machhendranath* festivals, to determine the earthquake impacts on Nepal's intangible cultural heritage. Long-term research on the rites and festivals should be conducted by various experts of religions, tribes, customs, and habits to fully understand the impacts. As observed in this survey, neither festival was significantly impacted by the earthquake. Minor effects may be detected through detailed interviews with a widespread pool of stakeholders but this survey's time limitation did not allow for that. The necessity of documentation for retaining intangible cultural heritage was, however, obvious.

One of the themes of this survey was how intangible cultural heritage is placed in the cultural space—an important subject relating to the rehabilitation of local communities. However, it should be noted that special traditions do not always take precedence over other traditions when inheriting rites and festivals. For example, convenience may be preferred with ritual sense of space secondary. Cultural space should also be considered in the context of caste, position, and situation.

Finally, the main building of Ka-Nying Shedrub Ling Monastery for Tibetan Buddhism near Boudhanath in Kathmandu was previously damaged by an earthquake. The temple courtyard is the designated location for the *cham* dance performed each 29 December on the Tibetan calendar. Following the earthquake, refugee tents were erected in the temple courtyard making it impossible to use for dance. Information regarding each building's damages should be recorded and their associated religious and intangible cultural heritage significance should be preserved to the extent possible, even if it is difficult to publicly support each building.

(Chapter author: Hiromichi Kubota)

8. Summary of the Project and Issues for the Future

8. Summary of the Project and Issues for the Future

8.1. Summary of the project

In this project, which started in September 2015, the extent of damage to the cultural heritage of Nepal caused by the Gorkha Earthquake was assessed. In addition, methods of providing technical support for future recovery efforts were examined from the perspective of different fields. The chapters in this report present the results of the surveys carried out by experts in each field as well as the issues that were noticed during the survey process. This chapter summarizes all these aspects.

First, it was possible to confirm the initial reports about the enormous impact of the earthquake on the historical buildings and towns that constitute the highest representation of Newari culture. However, besides a few recently built reinforced concrete buildings, several historic buildings too were almost completely undamaged. Therefore, although there were differences depending on the region, it is possible to assume that the overall seismic force was not extremely large. The damage was presumed to be limited mainly to buildings with a low seismic resistance. However, it would be premature to declare that all historic buildings in Nepal are vulnerable to earthquakes; it is necessary to tread with caution and scientifically understand the factors that caused these differences in the level of damage that the buildings had experienced.

Moreover, it is extremely important to examine traditional building techniques and construction methods that were employed in each building. Most of the historic buildings in Nepal are made of wood and brick and the present damaged condition of the buildings offers possibly the only chance to observe how these two materials are combined in the construction. Many insights were obtained from doing this and further interesting aspects are expected to be learnt about ancient traditional building techniques so that their value as a cultural heritage becomes more significant. The repair and reconstruction process will have to make good use of the knowledge gained through this research and survey.

Understanding the structural behavior and seismic performance of historic buildings is also essential in minimizing the damage caused by earthquakes. An experimental analysis of two multi-storied buildings carried out in this project allowed us to understand the differences in the types of damage between them. However, there is still much information missing regarding the detailed mechanism of the collapse and the quantitative assessment of their structural strength. There are large differences in the strength of the materials used in various buildings and among different parts of the same building. Therefore, it is necessary to obtain precise data through sampling and material testing and develop an analysis method including models that accurately represent the characteristics of Nepali architecture.

Regarding emergency protection measures, a pilot case study of the sorting, storing, and documentation of salvaged members of collapsed buildings was carried out. During this process, it was noticed that even in the case of completely collapsed buildings, the damage suffered by individual parts was light. Therefore, if the salvaged parts are identified and properly stored, a highly accurate restoration using the original materials is possible. However, measures must necessarily be implemented until a full-scale repair is carried out to prevent further damage and stabilize buildings that escaped collapse. This aspect was not studied in the framework of the research and survey conducted in this project.

The obstacles for reconstruction are even larger in the case of historic settlements, which unlike single monuments comprise groups of buildings. To ensure safety, recover the whole settlement, and improve the living conditions of its inhabitants in a sustainable way, many issues persisted, which could not be resolved from the perspective of cultural heritage alone. These obstacles will have to be cleared one by one and an agreement will have to be undertaken between the government and the local community to achieve a realistic recovery plan. This is a complicated process requiring different kinds of specialized knowledge.

Although the focus of this project was on architectural heritage, intangible heritage always forms an essential aspect when considering a comprehensive protection of cultural heritage as well as recovery from the point of view of the local community. Although there are some buildings that retain their original functionality, such as religious buildings and places of everyday life, and others that have already lost it, such as the royal palaces, the spiritual meaning of each place is deeply rooted in the minds of the Nepali people. The restoration, reconstruction, and recovery processes need to take into account not only the material and formal aspects but also these intangible aspects.

8.2. Issues for the future

The objective of this project was to provide technical support to the post-earthquake recovery in the field of cultural heritage, and its focus was on specialized surveys. However, from the beginning of the project, the Government of Nepal had expressed high hopes in the possibility that our country would directly take part in the physical recovery, i.e., the restoration and reconstruction of damaged buildings. Strengthening the capacities of the target country through transmission of techniques and training of human resources remains an effective approach to do this. However, the fastest way to accomplish this is to continuously carry out projects led by Japanese experts and to transmit this technical knowledge to the local workers who are part of the day-to-day activities on site: the so-called OJT (On the Job Training) based methodology. Therefore, while it may not be possible to achieve this in the framework of this project, a long-term deployment of experts on site should be actively considered. This would also be effective in overcoming the limitations of this project, which is a short-term mission. Namely, the process can be made more effective by carrying on activities outside the period of the missions, by making preparations in advance of the arrival of survey groups, and, more importantly, by building bonds of trust with the stakeholders from the Nepalese side.

There are many issues in Nepal that need to be resolved to accomplish the restoration and reconstruction of cultural heritage, especially the architectural heritage, with regard to both principles and methodologies. Especially in the case of properties inscribed in the World Heritage List, a thorough discussion is necessary to ensure that authenticity is preserved. In most of the previous repair works carried out in Nepal, documentation is either nonexistent, or inaccessible. This is a major obstacle in the technical and structural surveys of damaged buildings. However, the surveys in this project have also revealed that traditional architecture in Nepal may have its own hidden techniques to resist earthquakes. Therefore, it is not proper to simply introduce the latest techniques and employ the standard methodologies of the developed countries. It is necessary to establish a set of guidelines that includes appropriate repair techniques taking into account the local conditions with a proper understanding of the cost factor and availability of techniques, materials, and human resources.

While full-scale recovery has not yet started, several countries have already expressed their intention to support and take part in it. There are high expectations for recovery of cultural heritage as well, and an adequate coordination between different projects is desirable to avoid large differences in principles and practices and to boost the effect of each individual project. Coordinating with different international organizations such as the UNESCO as well as the different project frameworks of the various national organizations is needed to realize effective support to the disaster-struck area. We, as a team of experts, also hope to perform our task effectively in this scheme. All of us who are involved in the post-disaster recovery efforts feel a sense of responsibility in turning the tragedy of the disaster into an opportunity to conserve the cultural heritage of Nepal and wish to continue our work in the spirit of cooperation.

(Chapter author: Masahiko Tomoda)

Appendix：Names of the Temples included in this report in Hanumandhoka Durbar Square　　ver.20160418

＊In this report, The English names of buildings are mainly quoted from “UNESCO Kathmandu 2015”

	NRICPT (This report)		UNESCO Kathmandu 2015	*Architecture of the Newars 2011*	*Kathmandu Valley 1975*		*Hanumāndhokā Rājyadurbār 1976*
No.	Japanese	English	English	Newar+English	English	Newar	Newar
1	ハヌマンドカ王宮広場	Hanumandhoka Durbar Square	Hanuman Dhoka Durbar Square				
2	ハヌマンドカ王宮	Hanumandhoka		*Hanumāndhokā Palace*			
3	王宮前広場	Durbar Square					
4	アガンチェン初層	First story of Aganchen					
5	モハン･チョクおよびスンダリ･チョク西棟	West wing of Mohan Chok and Sundari Chok					
6	ハヌマン像	Hanuman Image		*Hanumān*	Hanuman	*Hanumān*	*Hanumān*
7	ジャガナート寺祠堂	Shrines of Jaganath Temple					
8	△△チョク西棟	△△ Chok West Wing					
9	モハン･チョク南西角部（アガンチェン下）	South-West Courner of Mohan Chok（Below Aganchen）					

△寺院番号

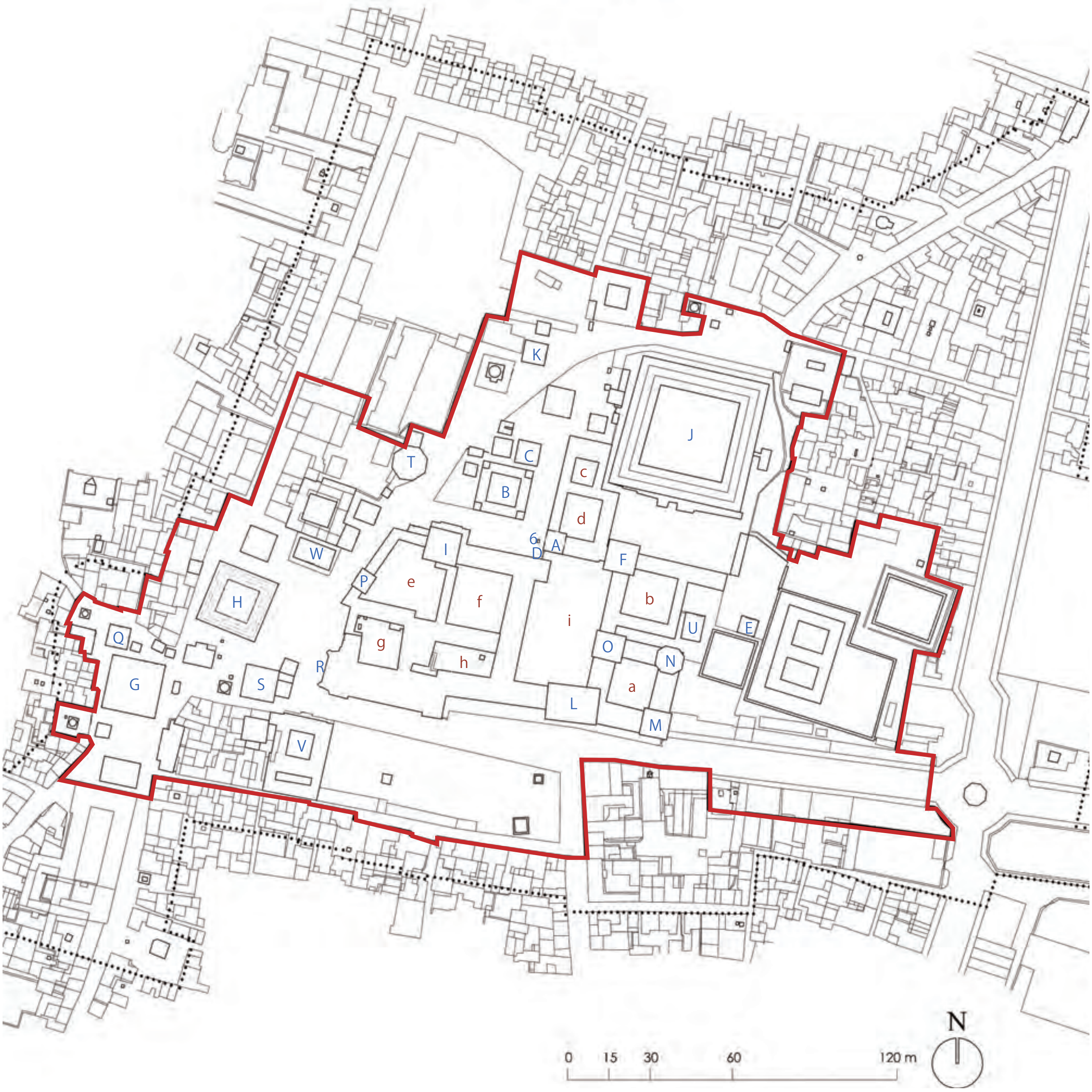
A	アガンチェン寺	Aganchen Temple	Aagan Temple	*Āganchen*	Aagan Mandir	*Āgā Temple*	*Āgamchemmandir*
B	ジャガナート寺	Jagannath Temple	Jagannath Temple	*Cārnārāyana temple*	Jagannath Temple	*Jagannāth*	*Jagannāth ko Mandir*
C	ゴピナート寺	Gopinath Temple	Gopinath Temple (Srikrishna Mahavishnu)	*Nārāyana*	Gopinath Temple	*Gopināth*	
D	ハヌマンドカ正門	Hanumandhoka Gate	-	-	-	-	*Suvrṇadvāra*
E	シヴァ寺	Shiva Temple	Mahadev Temple	*Mahādeva temple*	Mahadev	*Mahādev*	
F	パンチャムキ・ハヌマン寺	Panchamukhi Hanuman Temple	Pancha Mukhi Hanuman Temple	*Bhagavatī temple <Pañcamuki Hanumān>*	Pancha Mukhi Hanuman	*Pancamukhi Hanumān*	*Panchamukhi Hanumān ko Mandir*
G	カシタ・マンダパ	Kastha Mandap	Kastha Mandap Temple	*Kāṣṭhamaṇḍapa*	Kashta Mandap	*Kāṣṭha Maṇḍap*	*Marusatte (Kāṣthamaṇḍap)*
H	マジュ・デガ寺	Maju Dega Temple	Maju Dega Temple	*Mahādeva temple <Mājudevala>*	Maju Dega	*Māju Dega*	
I	デグ・タレ寺	Degu Talle Temple	Degu Talle Temple	*Degutale temple*	Degu Talle Mandir	*Degu Talle Mandir*	*Degutaleju ko Mandir*
J	タレジュ・バワニ寺	Taleju Bhawani Temple	Taleju Bhawani Temple	*Taleju temple*	Taleju Bhawani	*Taleju Bhavani*	*Taleju ko Mandir*
K	パンチャムキ・ラクシュミ・ナラヤン寺	Panchamukhi Lakshmi Narayan Temple	Pancha Mukhi Lakshmi Narayan Temple	*Māhaviṣṇu temple*	Lakshmi Narayan	*Lakṣ́mi Nārāyaṇ*	*Lakṣmīnārāyaṇ ko Mandir*
L	バサンタプル・バワン	Basantapur Bhawan	Basantapur Bhawan	*Basantapur tower*	Basantapur Bhawan	*Basantapur Bhavan*	
M	ラリトプル・バワン	Lalitpur Bhawan	Lalitpur Bhawan	-	Lalitpur Bhawan	*Lalitpur Bhavan*	
N	バクタプル・バワン	Bhaktapur Bhawan	Bhaktapur Bhawan	-	Bhaktapur Bhawan	*Bhaktapur Bhavan*	
O	キルティプル・バワン	Kirtipur Bhawan	Kirtipur Bhawan	-	Kirtipur Bhawan	*Kirtipur Bhavan*	
P	バグマティ寺	Bhagvati Temple	Bhagvati Temple	*Mahīpātindra Nārāyana temple <Kanelcok Bhagavatī>*	Bhagvati	*Bhagvati*	*Bhagvatī ko Mandir*
Q	シヴァリンガ寺	Shivalinga Temple	Shivaling Temple	*Two-tiered Mahādeva temple*	Shivaling	*Ṡivalinga*	
R	ガディ・バイタク	Gaddi Bhaithak	-	*The Gaddi Bhaithak*			
S	ナラヤン寺	Narayan Temple	Narayan Temple	*Triple-tiered Trailokyamohan temple*			
T	チェイスン・デガ寺	Chasin Dega Temple	Chasin Dega Temple	*Triple-tiered octagonal Krsna temple*	Casi̅ Dega		
U	ダサイン・ガル寺	Dasain Ghar Temple	Dasain Ghar Temple	*Dasāīnghar*	Dasain-Ghara (Kota Ghara)	*Dā̃shai Ghara*	
V	クマリ・バハ	Kumari Bahal	Kumari Bahal	*Kumārībāhā*	Kumari Baha	*Kumāri Bāhāl*	
W	ナヴァ・ジャギニ・ハウス	Nava Jogini House	Nava Jogini House	*Tārakeśvara temple with Aṣṭamātṛkā (Siva-Pārvatī temple)*	Nava Jogini	*Nava Yogini*	

□Chok番号

a	ローン･チョク	Lohan Chok	Lohan Chok	*Lvahancuka*	Lohan Chok	*Lhōcok*	*Vasantpurcok*
b	ムール･チョク	Mul Chok	Mul Chok	*Mūcuka*	Mool Chok	*Mulcok*	*Mulcok*
c	スンダリ･チョク	Sundari Chok	Sundari Chok	*Sundaricuka*	Sundari Chok	*Sundaricok*	*Sundarcok*
d	モハン･チョク	Mohan Chok	Mohan Chok	*Mohancuka*	Mohan Chok	*Mohancok*	*Mohancok*
e	マサン･チョク	Masan Chok	-	*Maśāncuka(Karnel cuka)*	-	-	*Kanheholcok*
f	ダーク･チョク	Dakh Chok	-	*Dakhcuka*	-	-	*Dākhacok*
g	ヌルチェン･チョク	Nhulchem Chok	-	*Nhuchencuka*	-	-	*Nhulchecok*
h	ラモ･チョク	Lamo Chok	-	*Lamocuka*	-	-	*Lāmcok*
i	ナサル･チョク	Nasal Chok	Nasal Chok	*Nasalcuka*	Nasal Chok	*Nasalcok*	*Nasalcok*

HANUMAN DHOKA DURBAR SQUARE

MONUMENT ZONE



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Project for International Contribution to Cultural Heritage Protection

Project for Investigation of Damage Situation of Cultural Heritage in Nepal

Project Report

2016