Preliminary Damage Survey Reporting Seminar of JSCE at University of Tokyo

Nepal Gorkha Earthquake, 2015

2015年4月25日 ネパール、ゴルカ地震

Earthquake Engineering Group
Ehime University Team
JSCE, JGS, JAEE and ATC3 delegates

Shinichiro Mori, Prof., GPI

mori@ehime-u.ac.jp

Structure of Ehime University Team

Ehime University Investigation Team

(A team of joint delegate from JSCE, JGS, JAEE, and ATC-3)

Members

Leader	Okamura, M.	Professor (Geotechnical Engineering)	Geotechnical Group
PI	Mori, S.	Assoc. Professor (Str. &Geot. Earthquake Engineering)	
	Bhandary, N.P.	Assoc. Professor (Landslide Engineering)	
	Narayan, S.	Researcher (PhD student, NSET)	Geotechnical Group
	Deepak	PhD student	Structural Group
	Sweata	PhD student	Structural Group
	Umesh	MC student	Geotechnical Group
	Hazarika Hemanta	Professor (Kyushu University)	Geotechnical Group
	Hiroshi Fukuoka	Professor (Niigata University)	Landslide Group

Collaborators

Deepak Raj Bhat	Lecturer (Tribuvan University)	Former student
Bigyan Upadhayay	Structural Engineer	Former student

Structural & Geotechnical Earthquake Engineering Group

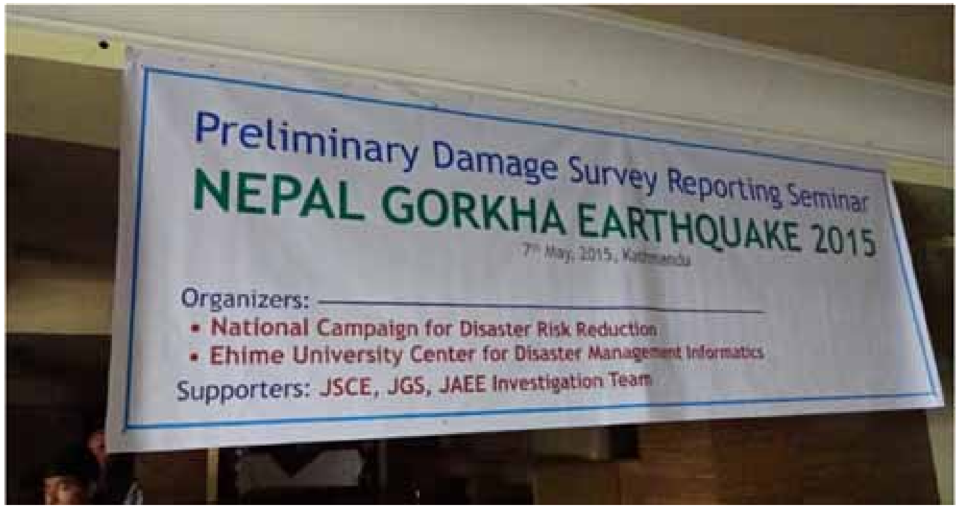
PI	Mori, S. Assoc.	Professor (Str. &Geot. Earthquake Engineering)		
	Deepak	PhD student	Structural	
	Sweata	PhD student	Structural	
Collaborators				
	Deepak Raj Bhat	Lecturer (Tribuvan University)		Former student
	Bigyan Upadhayay	Structural Engineer		Former student

Schedule

May 1	Arrival and installation of seismometers at 3 sites/ S. Mori & N.P. Bhandary
May 2	All around Kathmandu Municipality and the installation, DMG-NSC
May 3	Bhaktapur/day time, Information Sharing Meeting/evening
May 4-6	Investigation in Kathmandu & surroundings, and microtremor survey
May 7	Preliminary Survey Reporting Seminar for Nepali people (2 hours)

Ehime University Team Members

Preliminary Damage Survey Reporting Seminar May 7



Organizers

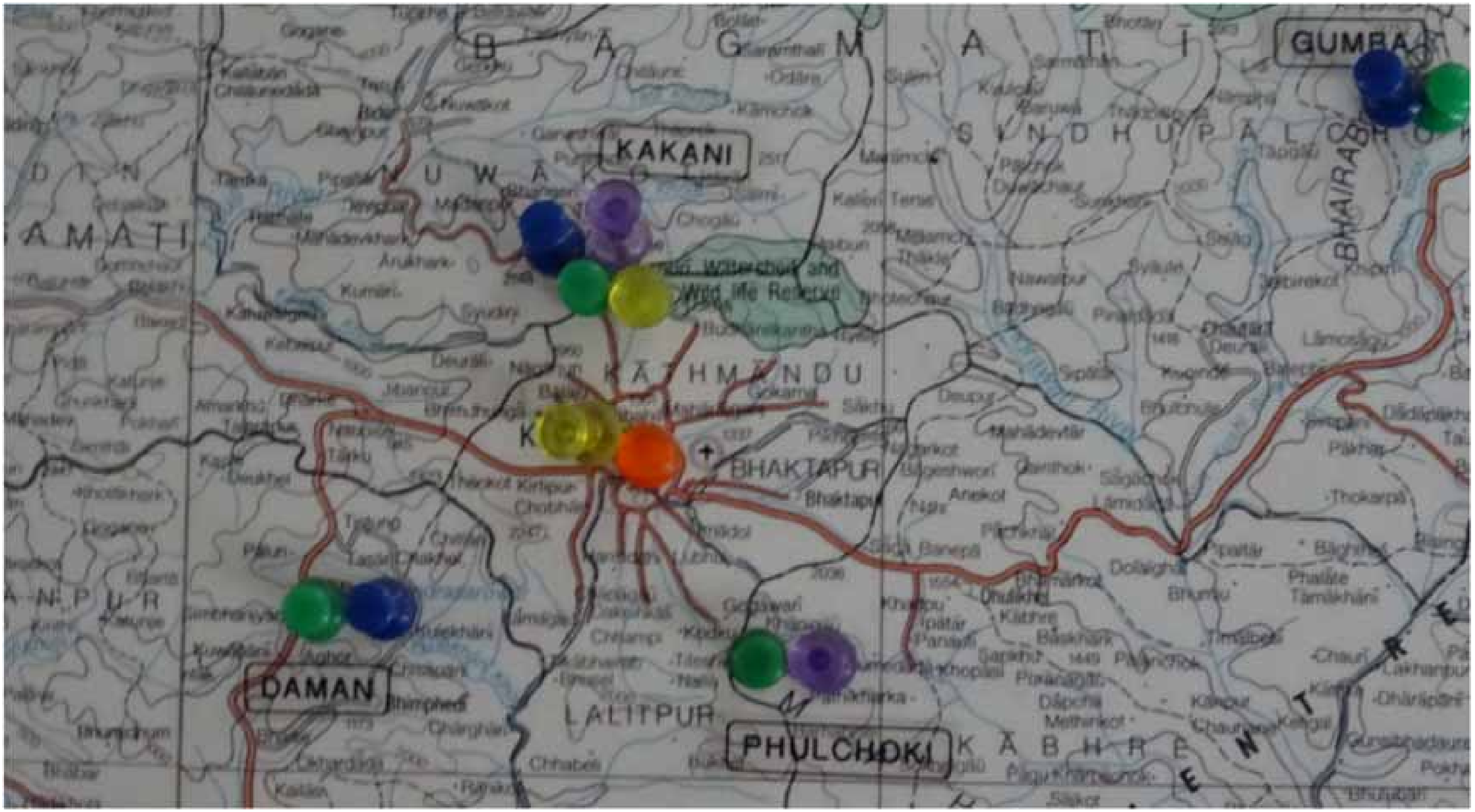
- National Campaign for Disaster Risk Reduction

- Ehime University Center for Disaster Management Informatics

Supporters: JSCE, JGS, JAEE

More than 120 Nepali people gathered from Parliament, Governments, Institution, etc.

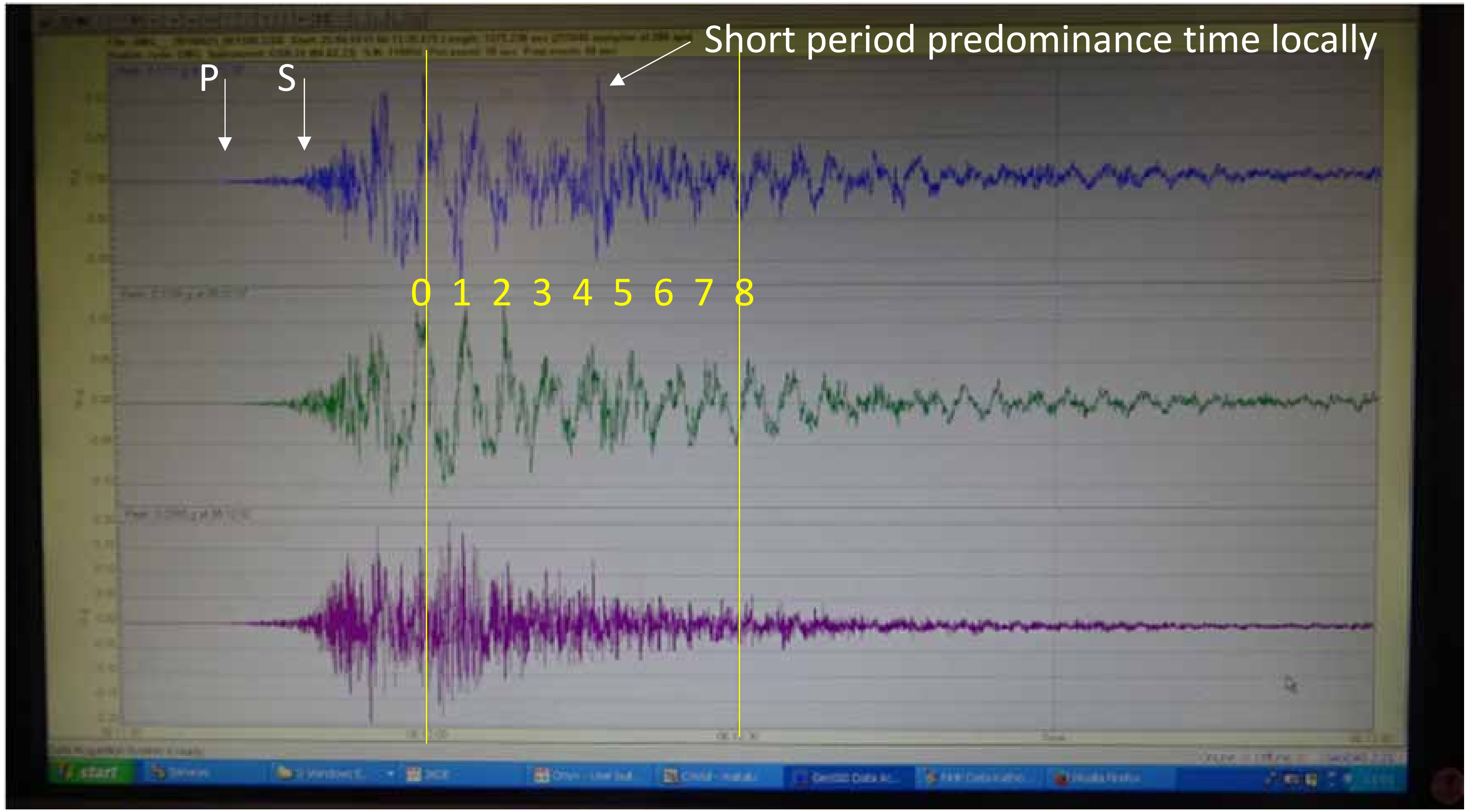
National Seismological Centre (NSC), DMG



Sensors in and around Kathmandu Basin

Yellow: Accelerometers, Blue: GPS

DMG-NSC Acceleration at KTM



0:11’30”   0:12’00”   0:12’30””   0:13’00”   0:13’30”

NS, EW, UD/ EW component has approximately 4 second predominance

USGS Kanti Path

CESMD

Information for Strong-Motion Station

Kanti Path, Kathmandu, Nepal
USGS - NSMP Station KATNP

[Earthquakes recorded by this station]

Latitude	**27.7120 N**
Longitude	**85.3160 E**

Download Table

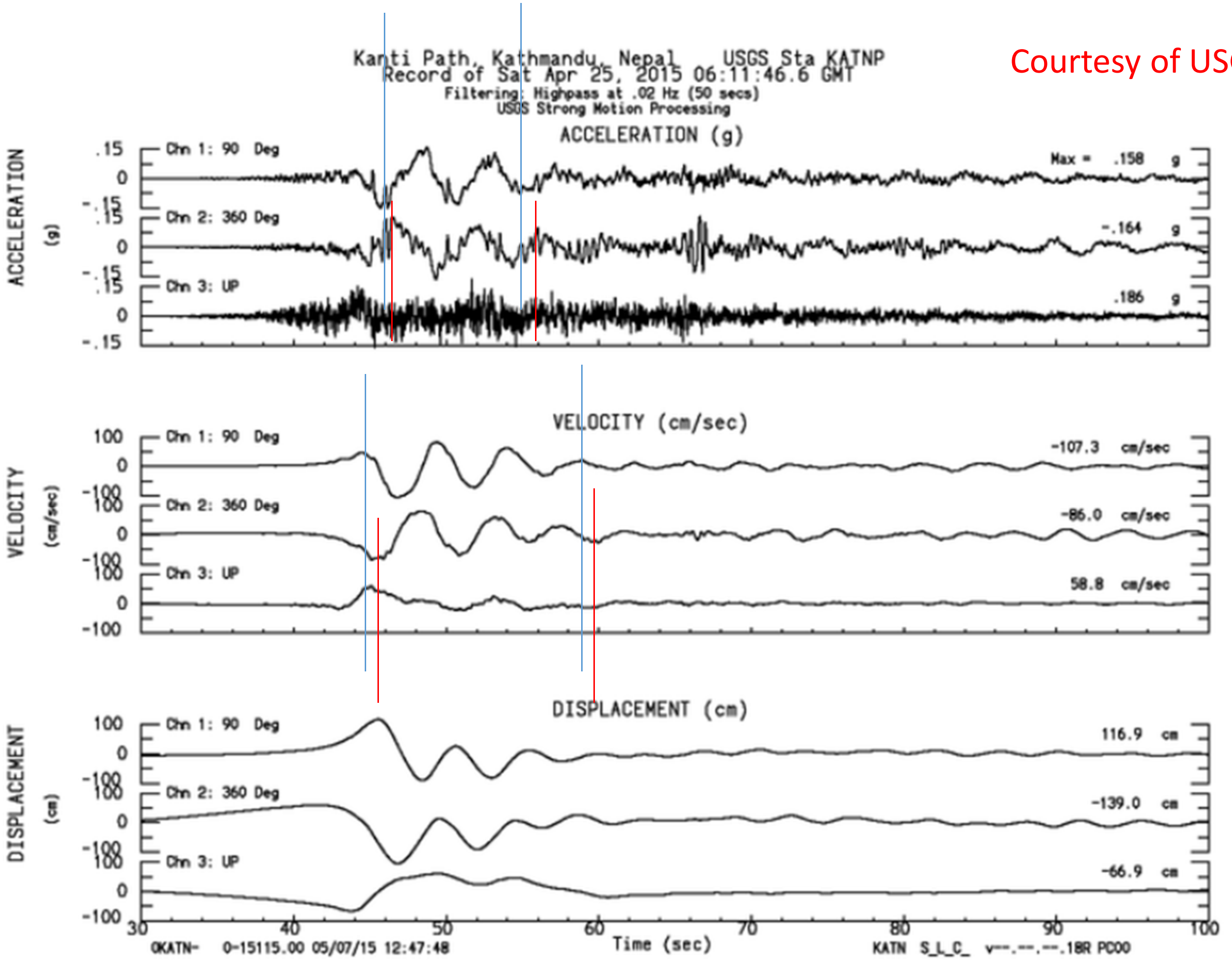
Last Update: 2015-05-07 15:40 (Pacific)

Station	Code /ID	Network	Distance (km)		Horiz Apk (g)		View	Download
			Epic.	Fault	Ground	Struct.		
Kanti Path, Kathmandu, Nepal	KATNP	USGS	59.9	13.9	**0.164**	--		

Reset Download

USGS opened digital data of acceleration at Kanti Path, KTM.

Time histories of ground motion at Kanti Path, Kathmandu



Courtesy of USGS

Acceleration
90deg EW 0.158 g
360deg NS 0.164 g
Up UD 0.186 g

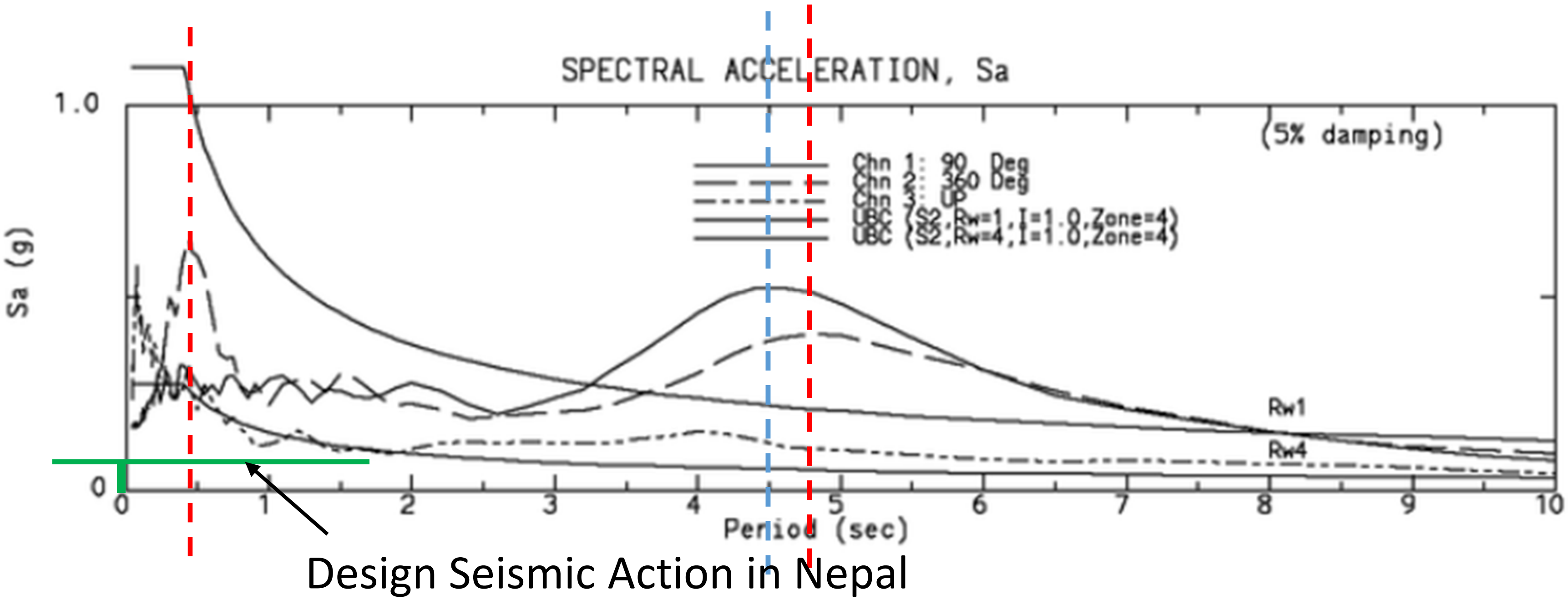
Velocity
90deg EW 107 cm/s
360deg NS 86 cm/s
Up UD 0.186 cm/s

Displacement
90deg EW 117 cm
360deg NS 139 cm
Up UD 67 cm

Three pulses in 13-15 seconds means 4.3-5 second component predominant in the main shock. On the other hand, short period components are less predominant.

5% damping Response spectra of ground motion at Kanti Path, Kathmandu

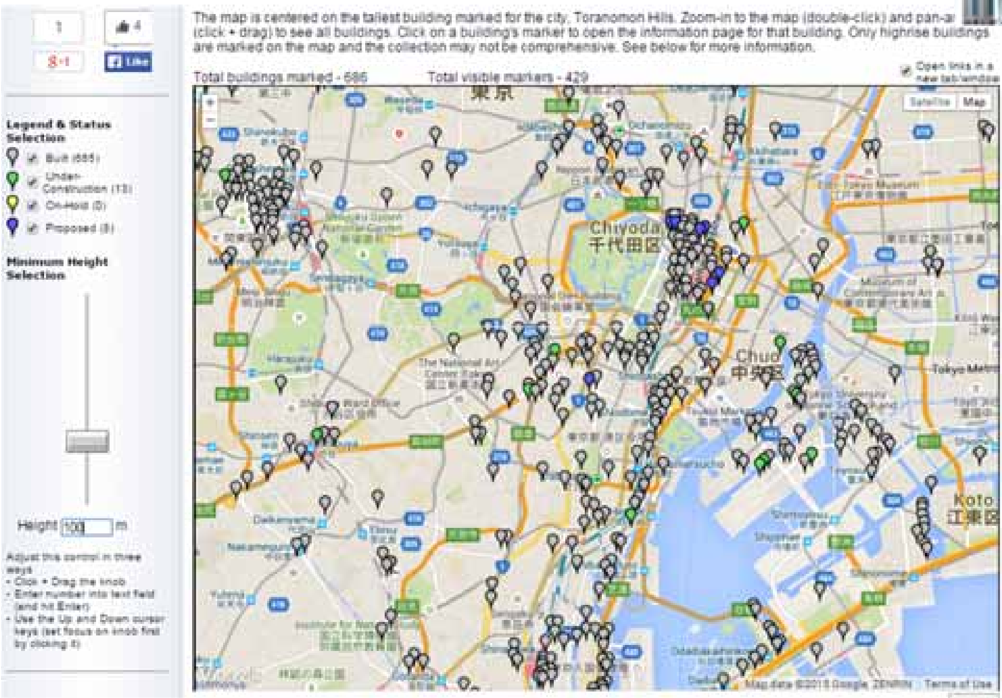
Courtesy of Dr. Unjoh, PWRI made from USGS data

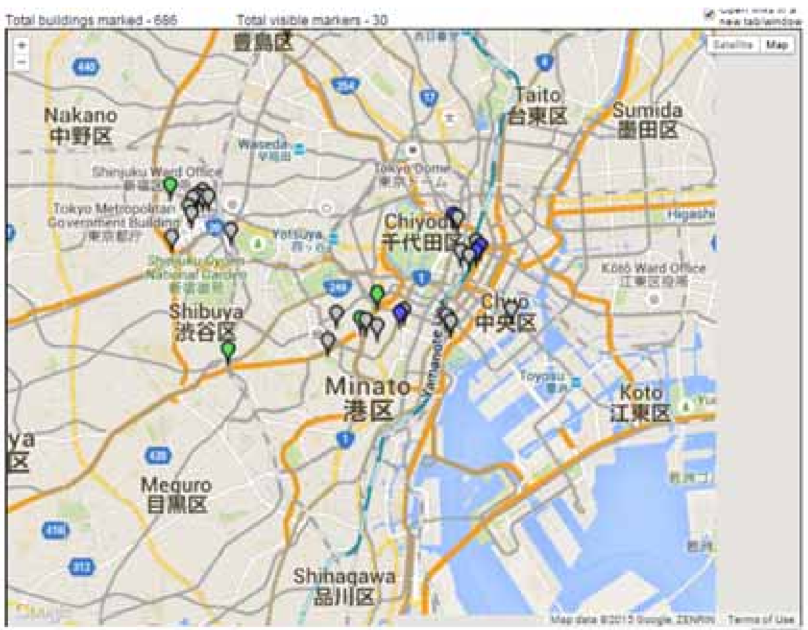


4.5 to 4.8 second is predominant in the range of longer natural period, and 0.4 second is another predominance (0.6 g) in the range of shorter natural period. This shorter period component is influential to most of buildings in Kathmandu. Comparing with design input of 0.08 g as per Nepali Seismic Design Code, Nepali buildings behaved quite well.

Imagine Japanese situation about skyscrapers

Picture and distribution maps cited from
http://skyscraperpage.com





Height>=100 m

Height>=200 m

Longer period components generated in the seismic source region and amplified though Kathmandu Basin should be studied in detail because of significant influence on high-rise buildings.

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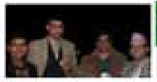
日本語



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Ehime University Alumni

S. N.	Full Name	Degree/Year of graduation	School/Faculty	Current affiliation
1	Yogesh Hari Shrestha	PhD (Agri)/1997	United Graduate School of Agriculture	Nepal Government
2	Moha Prasad Bhatta	PhD (Agri)/1998	United Graduate School of Agriculture	In USA (with UN)
3	Bishnu Prasad Dhakal	PhD (Agri)/1999	United Graduate School of Agriculture	In UK
4	Manoj Giri	Master (Law)/1999	Graduate School of Law and Letters	Freelance Lawyer (Nepal)
5	Bal Bahadur Parajuli	PhD (Eng)/2003	Graduate School of Sci. and Eng.	Self-employed (Nepal)
6	Ram Chandra Bhusal	PhD (Agri)/2003	United Graduate School of Agriculture	Winrock Int'l, Nepal
7	Netra Prakash Bhandary	PhD (Eng)/2003	Graduate School of Sci. and Eng.	Ehime University
8	Kishor Kumar Bhattarai	PhD (Eng)/2004	Graduate School of Sci. and Eng.	DOI, Nepal Government
9	Krishna Raj Pathak	PhD (Eng)/2005	Graduate School of Sci. and Eng.	DWIDP, Nepal Government
38	Purushottam Ghimire	PhD (Agri)/2014	United Graduate School of Agriculture	Nepal Agricultural Research Council

Prof. Netra Bhandary

Alumni (PhD & M)	38
Students	11
Total	49

Fields

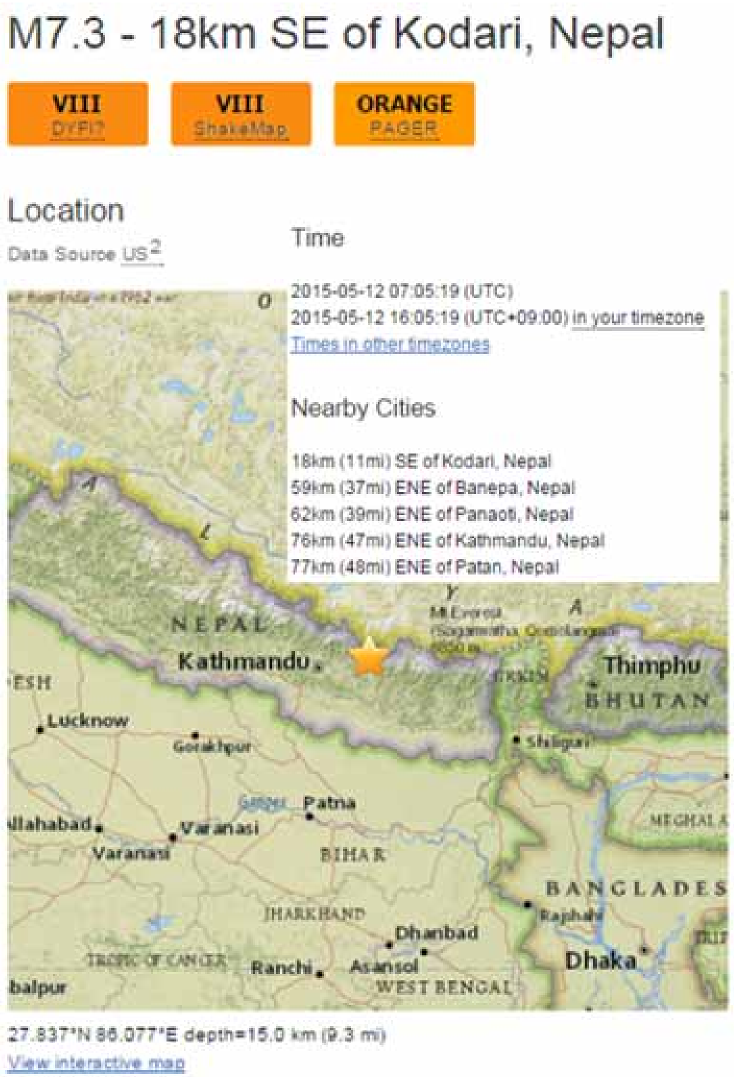
Engineering

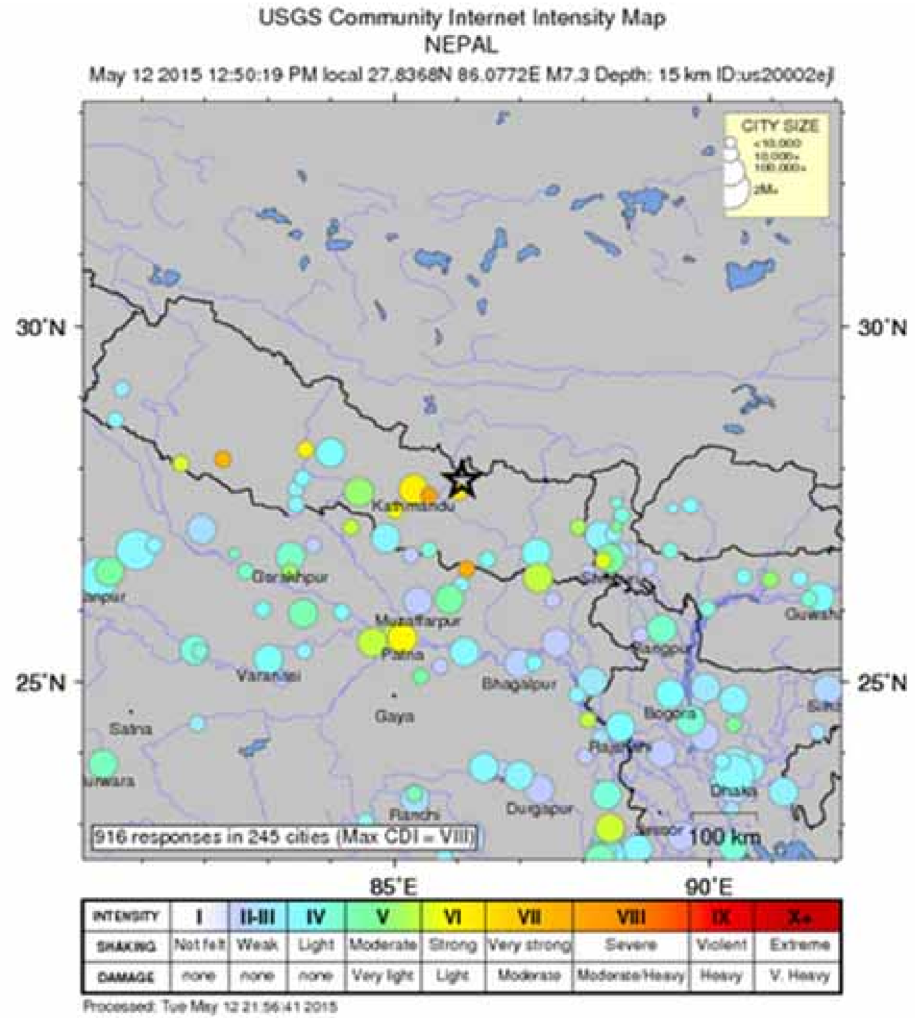
Agriculture

Etc.

M7.3 Aftershock of May 12, 2015 (Maximum AS)

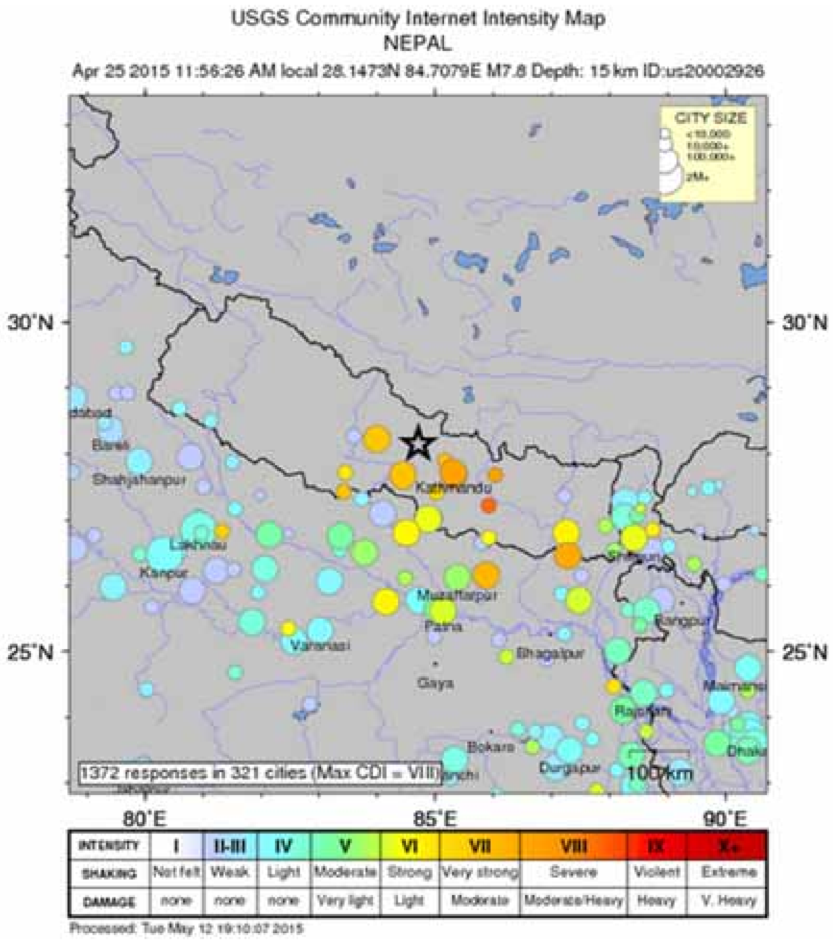
Source: USGS http://earthquake.usgs.gov





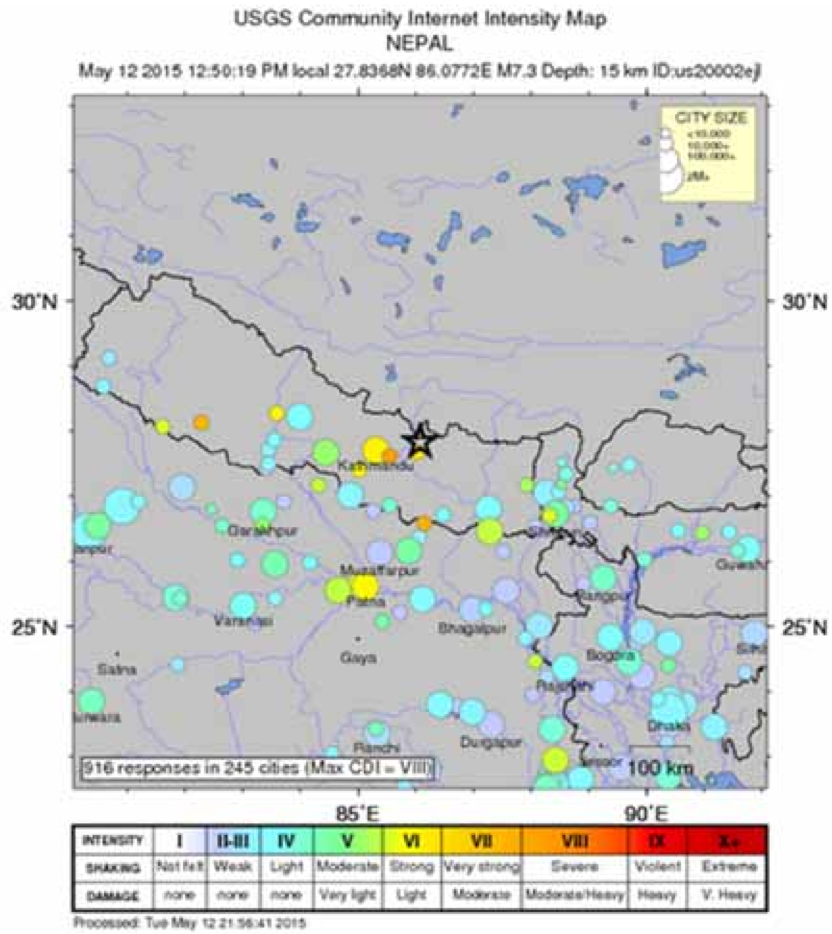
USGS Community Internet Intensity
M7.8 Gorkha EQ and M7.3 Aftershock of May 12

Main shock



Aftershock May 12

http://earthquake.usgs.gov



Questionnaire survey on seismic intensity seems very efficient especially in countries and regions without a sufficient seismic instrumental network.

M7.3 Aftershock of May 12, 2015 (Maximum AS)

Source: USGS http://earthquake.usgs.gov

M7.3 - 18km SE of Kodari, Nepal

VIII DYFI? | VIII ShakeMap | ORANGE PAGER

Location

Data Source US[2]

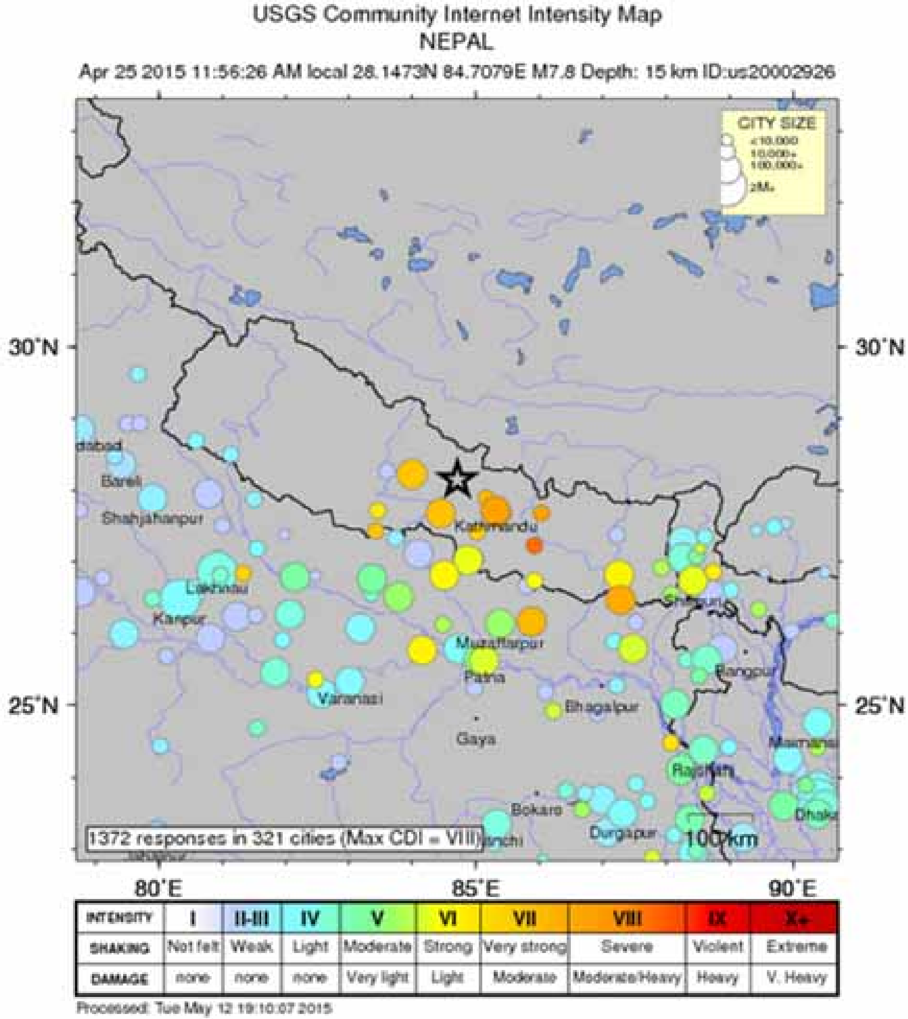
Time

2015-05-12 07:05:19 (UTC)
2015-05-12 16:05:19 (UTC+09:00) in your timezone
Times in other timezones

Nearby Cities

18km (11mi) SE of Kodari, Nepal
59km (37mi) ENE of Banepa, Nepal
62km (39mi) ENE of Panaoti, Nepal
76km (47mi) ENE of Kathmandu, Nepal
77km (48mi) ENE of Patan, Nepal

27.837°N 86.077°E depth=15.0 km (9.3 mi)
View interactive map



Structural & Geotechnical Earthquake Engineering Investigation

Aim

Investigation to obtain initial information to be utilized in followed detail investigation from the earthquake engineering point of view

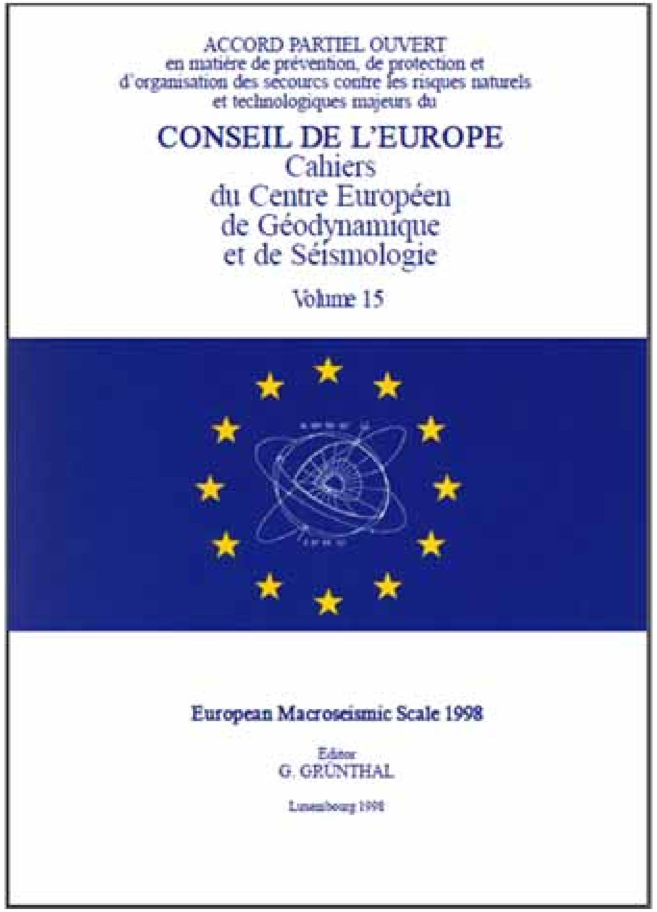
Investigation issues

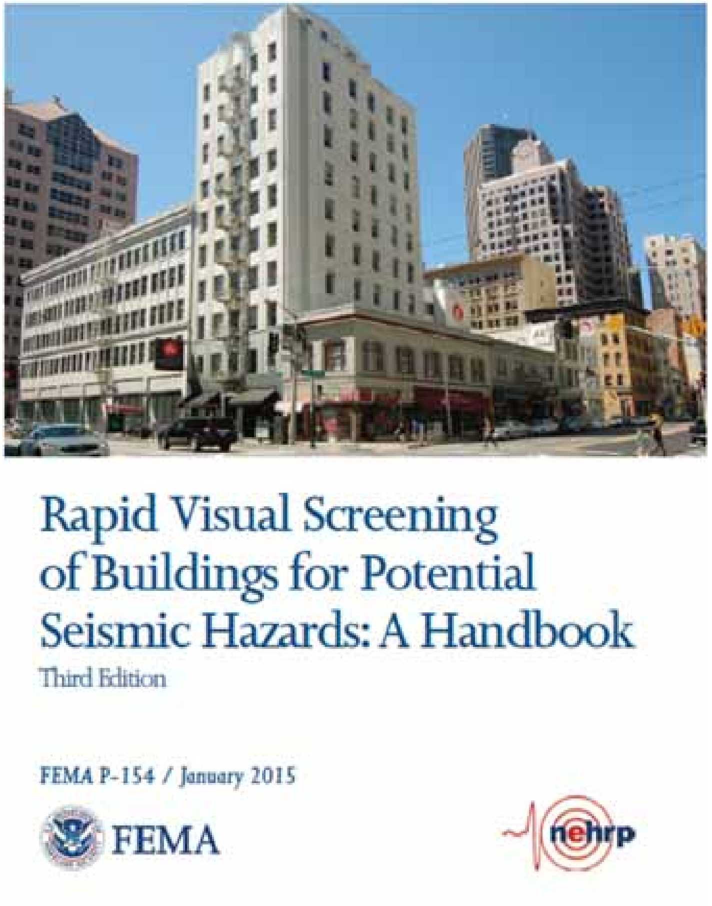
- **Tentative earthquake observation** to evaluate ground motions during the main shock of 2015 Nepal Earthquake at appropriate three sites for 3 months. One-week observation data for quick analysis and three-month observation
- **Damage assessment to buildings and structures** by overall survey in Kathmandu Valley and vicinities, and exhaustive survey in several typical areas in Kathmandu with observation in geotechnical aspects as well
- **Microtremor measurements on ground** to evaluate ground motion characteristics with focusing longer-period component amplification in the several typical damaged and undamaged area
- **Ambient vibration measurements on buildings and structures** to evaluate natural periods of vibration of buildings and structures with regard to types, ages and locations

Expected cooperation in investigation

- **Tentative earthquake observation** needs information of area categorization with regard to degree of damage to buildings, and provision of 4 to 5 candidates of place for installation of seismometers at three sites in the buildings or houses on the ground floor.
- **Damage assessment to buildings and structures** needs detailed maps of municipalities in and around Kathmandu Valley, and information of current observation and statistics about damage to the residential and other buildings.
- **Microtremor measurements on ground** needs information of area categorization with regard to degree of damage to buildings in municipalities in and around Kathmandu City.
- **Ambient vibration measurements on buildings and structures** needs need of evaluation of damaged buildings and structures including heritage sites with regard to being investigated in detail later for reconstruction and rehabilitation.

References for Damage Assessment





European (EMS98) and USA (FEMA) : Japan has used EMS98.

Damage assessment to buildings and structures

Table 0.2 Relative relationship between some building damage classifications

<table>
<tr><td>Judgment standard</td><td colspan="11">Slightly ← Damage grade → Serious</td></tr>
<tr><td>Disaster Relief Law</td><td></td><td colspan="2">"Ichibu-sonkai"</td><td colspan="4">"Hankai"</td><td colspan="4">"Zenkai"</td></tr>
<tr><td>Architectural Institute of Japan</td><td colspan="5"></td><td>"Keibi"</td><td colspan="2">"Shouha"</td><td>"Chuha"</td><td>"Taiha"</td><td>"Toukai"</td></tr>
<tr><td>European Macroseismic Scale 98</td><td>D0</td><td>D1</td><td colspan="2">D2</td><td colspan="3">D3</td><td colspan="3">D4</td><td>D5</td></tr>
</table>

http://iisee.kenken.go.jp/net/yokoi/methodology/00intro.htm

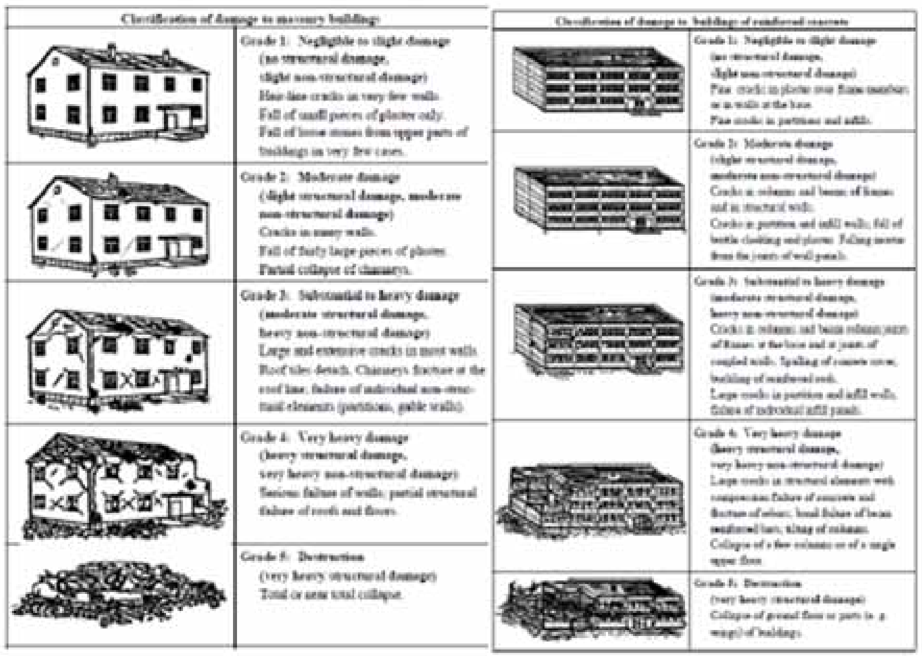
- **Damage assessment to buildings** will be conducted according to European Macroseismic Scale 1998 (EMS-98), which has been broadly used mainly for damage assessment of masonry buildings. Dominant types of buildings are unreinforced masonry (URM) buildings and reinforced concrete frame filled with brick buildings, which is not familiar in Japan. Damage assessment as per EMS-98 would be beneficial to compilation of damage assessment carried out by different institutes of different countries.
- The result of assessment as per EMS-98 can be equivalently converted to assessment scale issued by Architectural Institute of Japan (AIJ) and Japan Building Disaster Prevention Association (JBDPA). Consequently, the assessment results in all the types of building would be valuable to Japanese engineers.

RDA Nepal Sheet

Japan Academic Reconnaissance Team

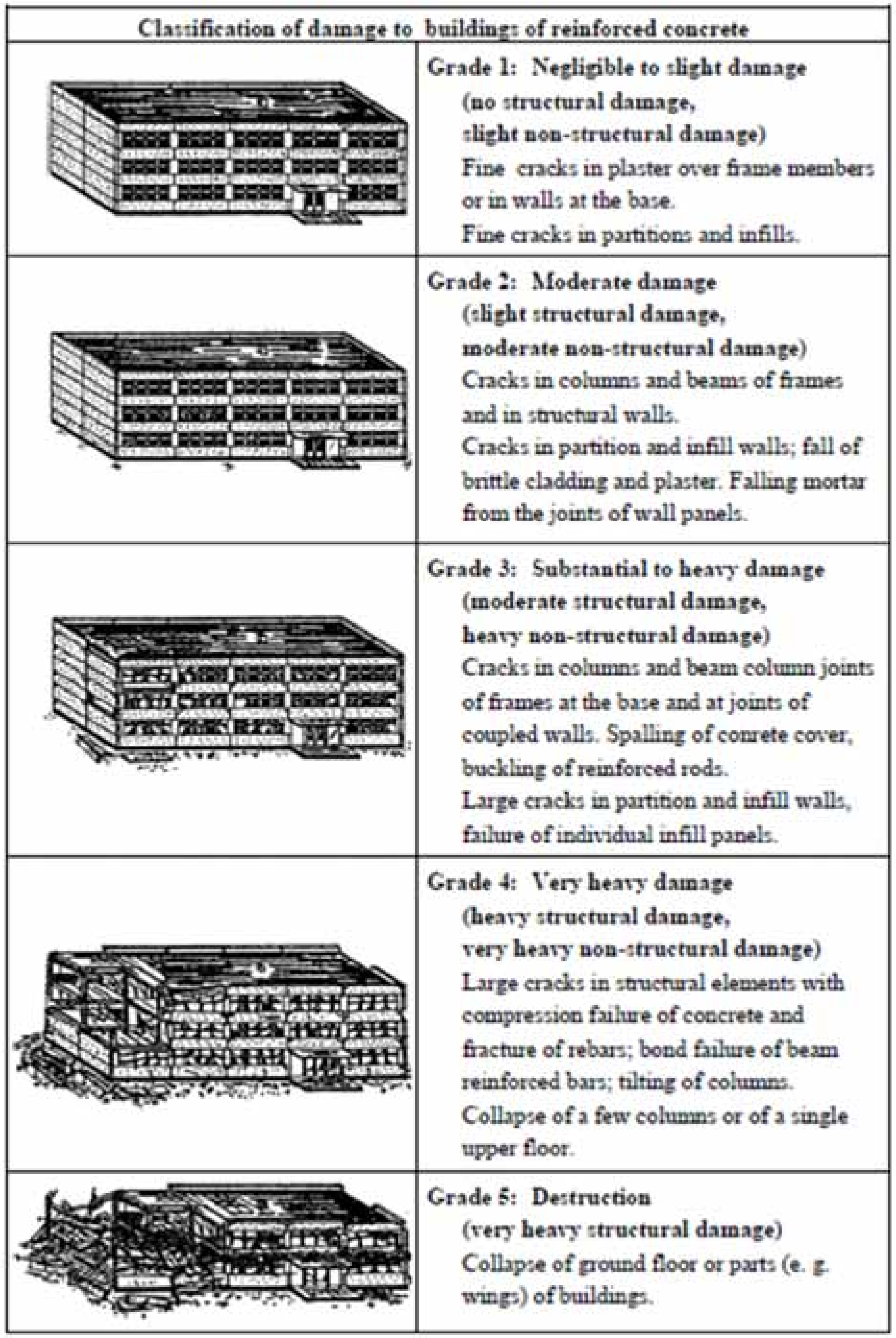
Rapid Damage Assessment on Buildings as per EMS-98

Sheet No.	
City	
Area name	
Street	
Address	
Longitude N	
Latitude E	
Date in 2015	
Time	
Name of investigator	
Use	Apartment Residence Store Office Hosital City/Town Hall School Factory Warehouse Others
Structure	RC RC frame with M wall UR Masonry R Masonry Wooden Steel Others
Type of structure	Frame Wall Others
Brick material	QC Burnt Burnt GQ Sun-burnt Sun-burnt BQ Sun-burnt
Mortal material	Cement Clay
Damage Grade	0 (No) 1 (Negligible to slight) 2 (Moderate) 3 (Substantial to heavy) 4 (Very heavy) 5 (Destruction)
Geotechnical observation	Settlement (cm, cm) Tilt (deg. /100 cm) Liquefaction Others
Interview Shaking intensity	I Not felt II Weak III Weak IV Light V Moderate VI Strong VII Very strong VIII Severe Violent X Extream
Drawing	Yes No
Photo No.	
Memorandum	
Drawing	Yes No



Nepal's RDA referred FEMA.

FEMA and EMS98 convertible.



Classification of damage to buildings of reinforced concrete	
	Grade 1: Negligible to slight damage **(no structural damage, slight non-structural damage)** Fine cracks in plaster over frame members or in walls at the base. Fine cracks in partitions and infills.
	Grade 2: Moderate damage **(slight structural damage, moderate non-structural damage)** Cracks in columns and beams of frames and in structural walls. Cracks in partition and infill walls; fall of brittle cladding and plaster. Falling mortar from the joints of wall panels.
	Grade 3: Substantial to heavy damage **(moderate structural damage, heavy non-structural damage)** Cracks in columns and beam column joints of frames at the base and at joints of coupled walls. Spalling of conrete cover, buckling of reinforced rods. Large cracks in partition and infill walls, failure of individual infill panels.
	Grade 4: Very heavy damage **(heavy structural damage, very heavy non-structural damage)** Large cracks in structural elements with compression failure of concrete and fracture of rebars; bond failure of beam reinforced bars; tilting of columns. Collapse of a few columns or of a single upper floor.
	Grade 5: Destruction **(very heavy structural damage)** Collapse of ground floor or parts (e. g. wings) of buildings.

EMS98 Damage classification (RC)

Grade 1: **Negligible to slight damage**

(no structural damage, slight non-structural damage) [Ichibu-Sonkai as per DRLoJ]

Grade 2: **Moderate damage**

(slight structural damage, moderate non-structural damage) [Ichibu-Sonkai as per DRLoJ]

Grade 3: **Substantial to heavy damage**

(moderate structural damage, heavy non-structural damage) [Keibi to Shouha as per AIJ]

Grade 4: **Very heavy damage**

(heavy structural damage, very heavy non-structural damage) [Chuha to Taiha as per AIJ]

Grade 5: **Destruction**

(very heavy structural damage)

Collapse of ground floor or parts (e. g. wings) of buildings. [Toukai as per AIJ]

EMS98 Damage classification (RC)

Grade 1: **Negligible to slight damage** (no structural damage, slight non-structural damage)

Fine cracks in plaster over frame members or in walls at the base. Fine cracks in partitions and infills. [Ichibu-Sonkai as per DRLoJ]

Grade 2: **Moderate damage** (slight structural damage, moderate non-structural damage)

Cracks in columns and beams of frames and in structural walls. Cracks in partition and infill walls; fall of brittle cladding and plaster. Falling mortar from the joints of wall panels.

[Ichibu-Sonkai as per DRLoJ]

Grade 3: **Substantial to heavy damage** (moderate structural damage, heavy non-structural damage)

Cracks in columns and beam column joints of frames at the base and at joints of coupled walls. Spalling of conrete cover, buckling of reinforced rods. Large cracks in partition and infill walls, failure of individual infill panels. [Keibi to Shouha as per AIJ]

Grade 4: **Very heavy damage** (heavy structural damage, very heavy non-structural damage)

Large cracks in structural elements with compression failure of concrete and fracture of rebars; bond failure of beam reinforced bars; tilting of columns. Collapse of a few columns or of a single upper floor. [Keibi to Shouha as per AIJ]

Grade 5: **Destruction** (very heavy structural damage)

Collapse of ground floor or parts (e. g. wings) of buildings. [Keibi to Shouha as per AIJ]

MMI (Modified Mercalli Intensity) 改正メルカリ震度階

表8.1.1-3　改正メルカリ震度階の説明(1931)

1：　地震計にのみ感ずる程度の地震、特に感じやすい状態にあるごく少数の人に感ずる程度

2：　ビルの上層に静止しているような少数の人にのみ感ずる。動きやすくつくられた物体はゆらぐ

3：　特にビル上層の屋内で,著しく感じ,止まっている自動車がわずかにゆらぐが,多くのものは地震とは思わない

4：　日中家内の多数の人に感じ,皿,窓ガラス,扉などがゆれ,止まっている自動車はかたりゆらぐ

5：　ほとんど全部の人に感じ多くの人は目が覚める。すわりの悪いものは倒れ振子時計が止まる

6：　すべての人に感じ、多くの人は驚いて戸外に飛び出す

7：　ほとんどすべての人が戸外に飛び出し、すわりの悪いものや、設計のよくないものにはかなりの損害がある

8：　堅ろうた建物にもかなりの損害があり、煙突、記念嚢街警戸箭雛譲奮を多少吹き出し、井戸水に変化がある

9：　堅ろうな建物にも損害があり、一部つぶれ、地面にき裂が著しく男われる

10：　石一工物の大部分破損、地面にき裂多大、鉄道線路の湾曲

11：　残存建物少なく、橋りょう破損、大き裂

12：　あらゆるものが破壊、地表に波形が見られ、あちゆるものは空中に投げ出される

http://www.kyoshin.bosai.go.jp/kyoshin/gk/publication/1/I-8.1.1.html

MMI(1931)	Europe, USA
MSK	Soviet, China
JMA(1884, 1908, 1908, 1936, 1949)	Japan
New JMA(1996)	Japan, instrumental

表8.1.1-1 気象庁震度階級の抽象的表現

震度1	少数の人だけに感ずる程度の強さ
震度2	全ての人に感ずる程度
震度3	家屋の揺れが分かる程度
震度4	恐怖を感ずる
震度5	被害が発生する
震度6	大被害
震度7	壊滅的被害

JMA scale (Japan Meteorological Agency Seismic Intensity Scale)
気象庁震度階

1884	5
1908	5
1908	5
1936	7, 0,I,…VI scaled
1949	8, VII added
1996	10, instrumentally, V and VI both splitted

表8.1.1-2　気象庁の震度階級の説明(1949)
括弧内は参考事項(1978)

0:無感　人体に感じないで地震計に記録される程度
(吊り下げ物のわチかにゆれるのが目視されたりカタカタと音が聞こえても、体にゆれを感じなければ無感である)

1:微震　静止している人や、特に地震に注意深い人だけに感ずる程度の地震(静かにしている場合にゆれをわずかに感じ、その時間も長くない。立っていては感じない場合が多い)

2:軽震　大勢の人に感チる程度のもので、戸障子がわずかに動くのがわかる程度の地震（釣り下げものの動くのがわかり、立っていてもゆれをわずかに感じるが、動いている場合にはほとんど感じない。眠っていても目をさますことがある)

3:弱震　家屋がゆれ戸障子がガタガタと鳴動し電灯のような釣り下げ物は相当ゆれ、器内の水面の動くのがわかる程度の地震（ちょっと驚くほどに感じ、眠っているひとも目をさますが、戸外にいる人もかなりの人に感じるが、歩いている場合感じない人もいる)

4:中震　家屋の動揺が激しく、すわりの悪い過分などは倒れ、器内の水はあふれ出る。また、歩いている人におm感じられ、多くの人々は戸外に飛び出す程度の地震
（眠っている人は飛び起き、恐怖感を覚える。電柱·立木などのゆれるのがわかる。一般の家屋の瓦がずれるのがあっても、また被害らしいものではない。撃い目まいを覚える)

5:強震　壁に割れ目が入り、墓石·石どうろうが倒れたり、煙突·石垣などが破損する程度の地震
(立っていることはかなりむずかしい。一般家屋に軽微な被害が出始める。軟弱な地盤では割れたりくずれたりする。すわりの悪い家具は倒れる)

6:烈震　家屋の倒壊は30%以下で、山くずれが起き、地割を生じ、多くの人々が立っていることができたい程度の地震
(歩行はむずかしく、はわないと動けない)

7:激震　家屋の倒壊が30%以上に及び、山くずれ地割れ、断層などを生じる

著者注:ここでの'地震'は'地震動'の意味

表8.1.1-1 気象庁震度階級の抽象的表現

震度1	少数の人だけに感ずる程度の強さ
震度2	全ての人に感ずる程度
震度3	家屋の揺れが分かる程度
震度4	恐怖を感ずる
震度5	被害が発生する
震度6	大被害
震度7	壊滅的被害

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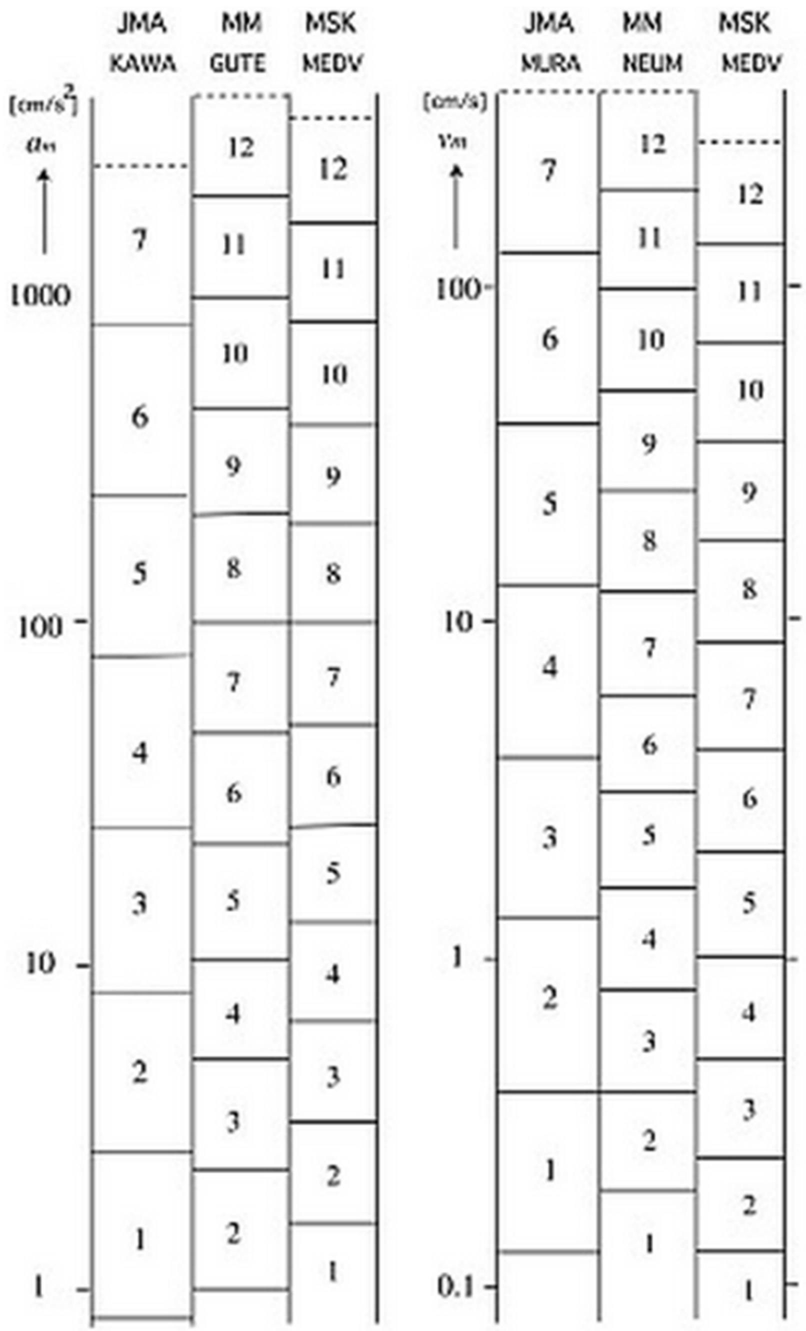


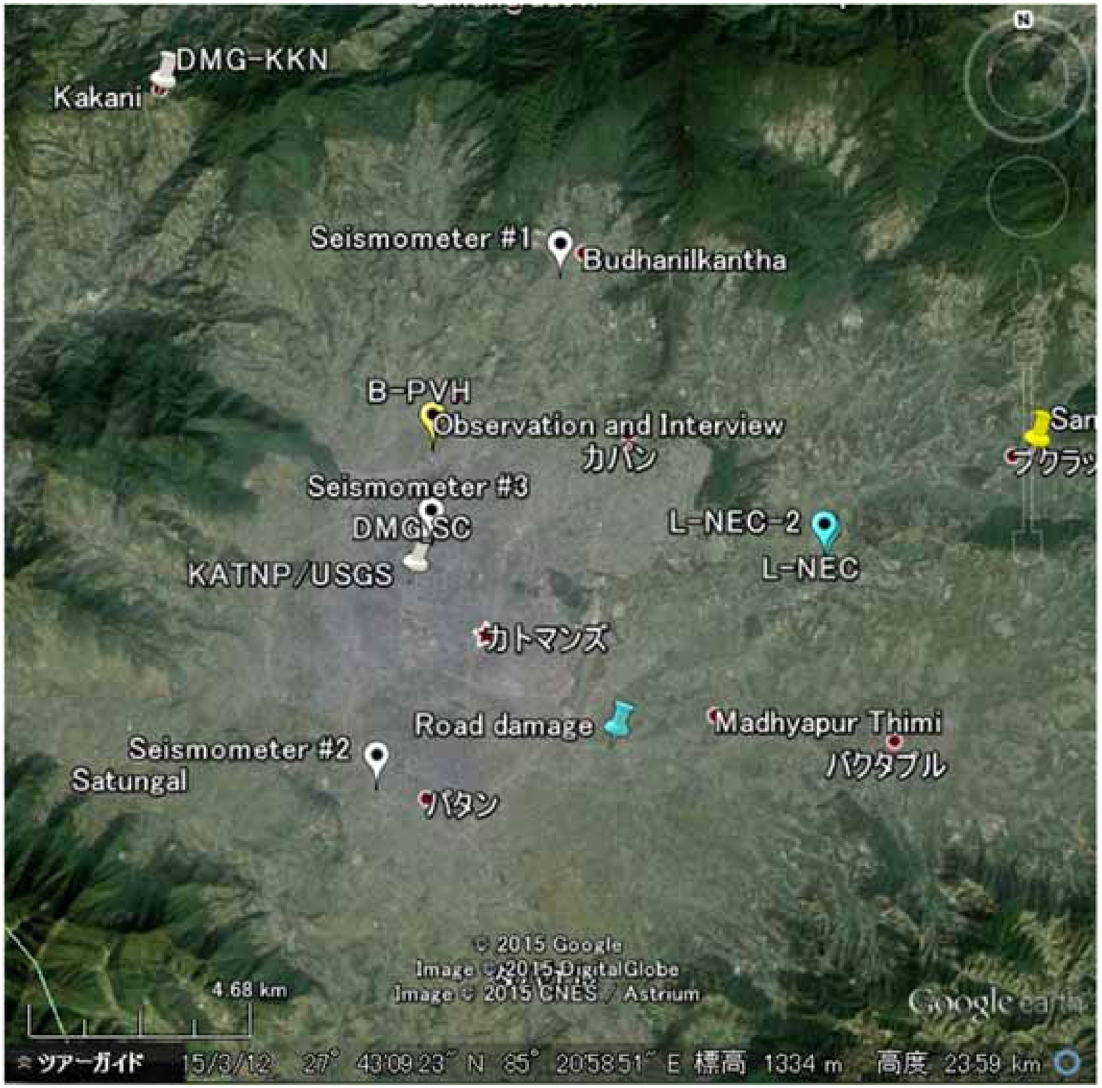
Correspondence of different scales with regard to acceleration and velocity of ground

Previous JMA scale (1949)

図8.2.1-1 **3種の震度階と物理量との関係.**
［**村松**(1967)**による**］
震度階：JMA;**気象庁旧震度階**、MM;**改正メリカリ震度階**、MSK;MSK**震度階**
出典：KAWA;**河角**(1943)、GUTE;Gutenberg and Richter(1942)、MEDV;Medvedev(1960)、NEUM;NEUMAN(1960)、MURA;**村松**(1967)

http://www.kyoshin.bosai.go.jp/kyoshin/gk/publication/1/I-8.2.1.html

Seismometers in Kathmandu Basin



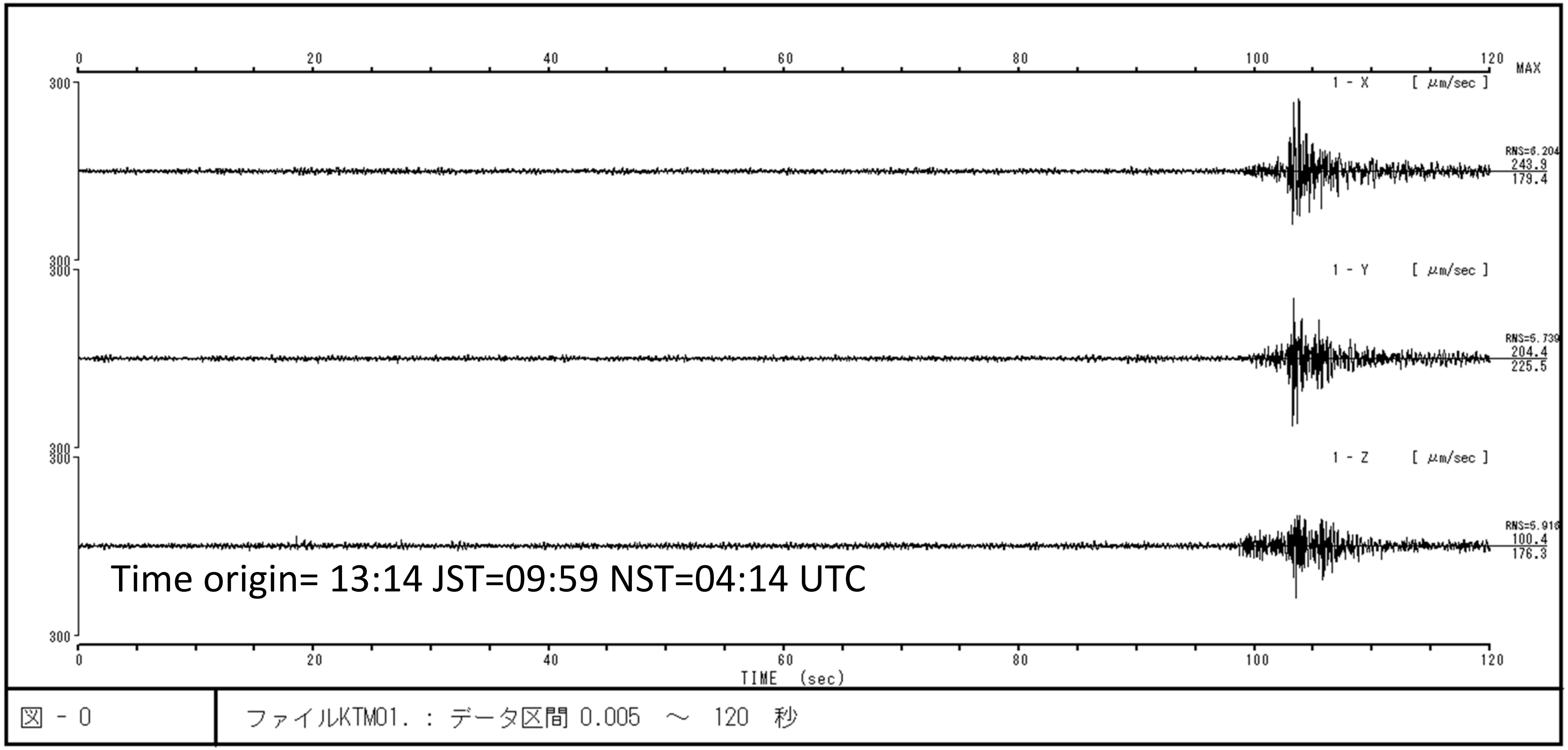
In order to study correlation between damage ratio and predominant period of ground vibration, our team carried out a kind of partial exhaustive survey along a roughly N-S running street. Eight members were divided to four groups. Each group has a Nepali member for guiding and interviewing.

Seismometers in Kathmandu Basin

#3 seismometer was moved to the house of Nepali PhD student of Ehime University. The house suffered no damage. As the result of interview her parent, seismic intensity there seems 5- in JMA scale.

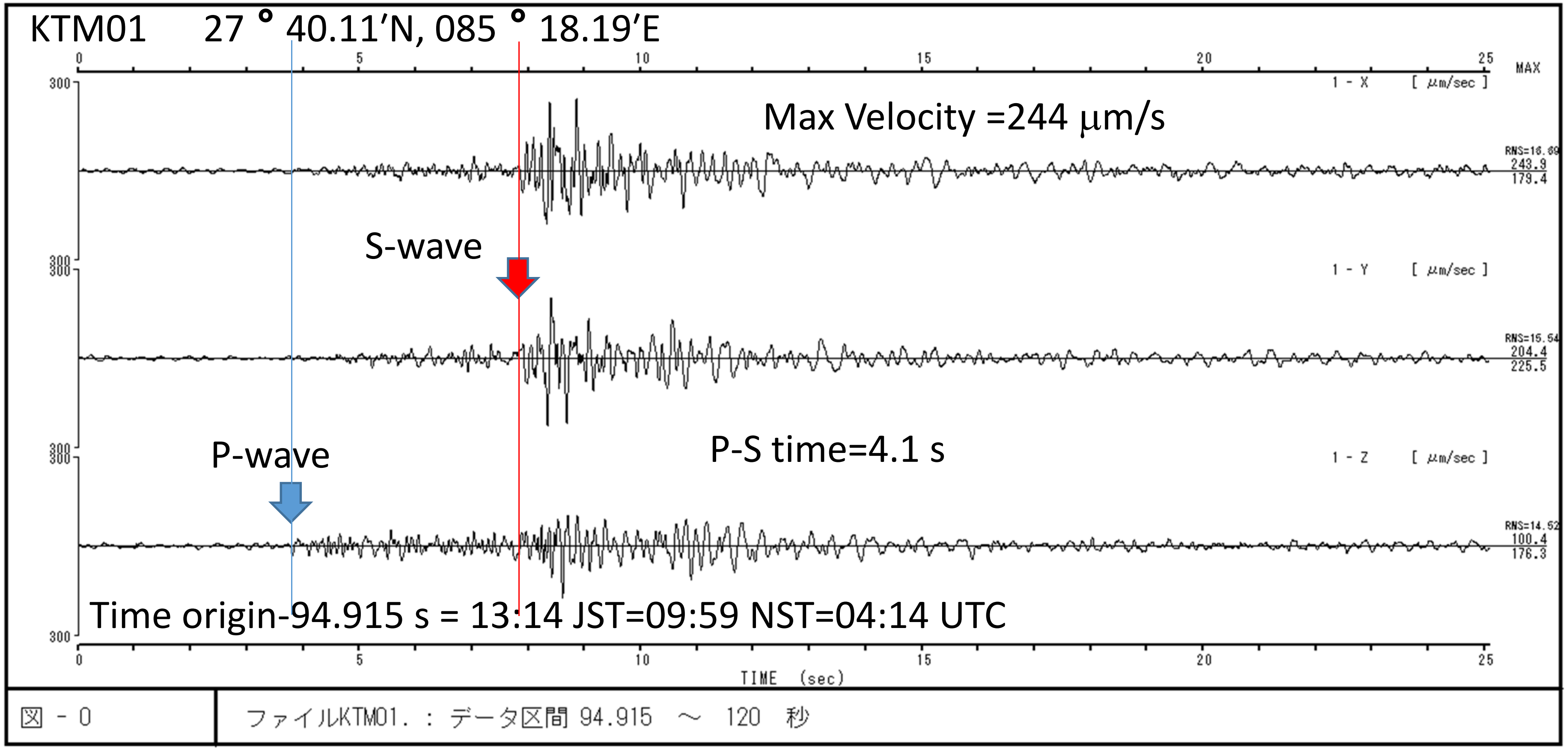
Time Histories of Velocity of Micro-tremor and Micro-earthquake at North Kathmandu

KTM01 27 ° 40.11’N, 085 ° 18.19’E



File name: KTM01, Sampling frequency: 200 Hz

Time Histories of Velocity of Micro-earthquake Motion at North Kathmandu



File name: KTM01, Sampling frequency: 200 Hz

Not reported by DMG

Time Histories of Velocity of Micro-tremor at North Kathmandu

KTM01 27 ° 40.11’N, 085 ° 18.19’E

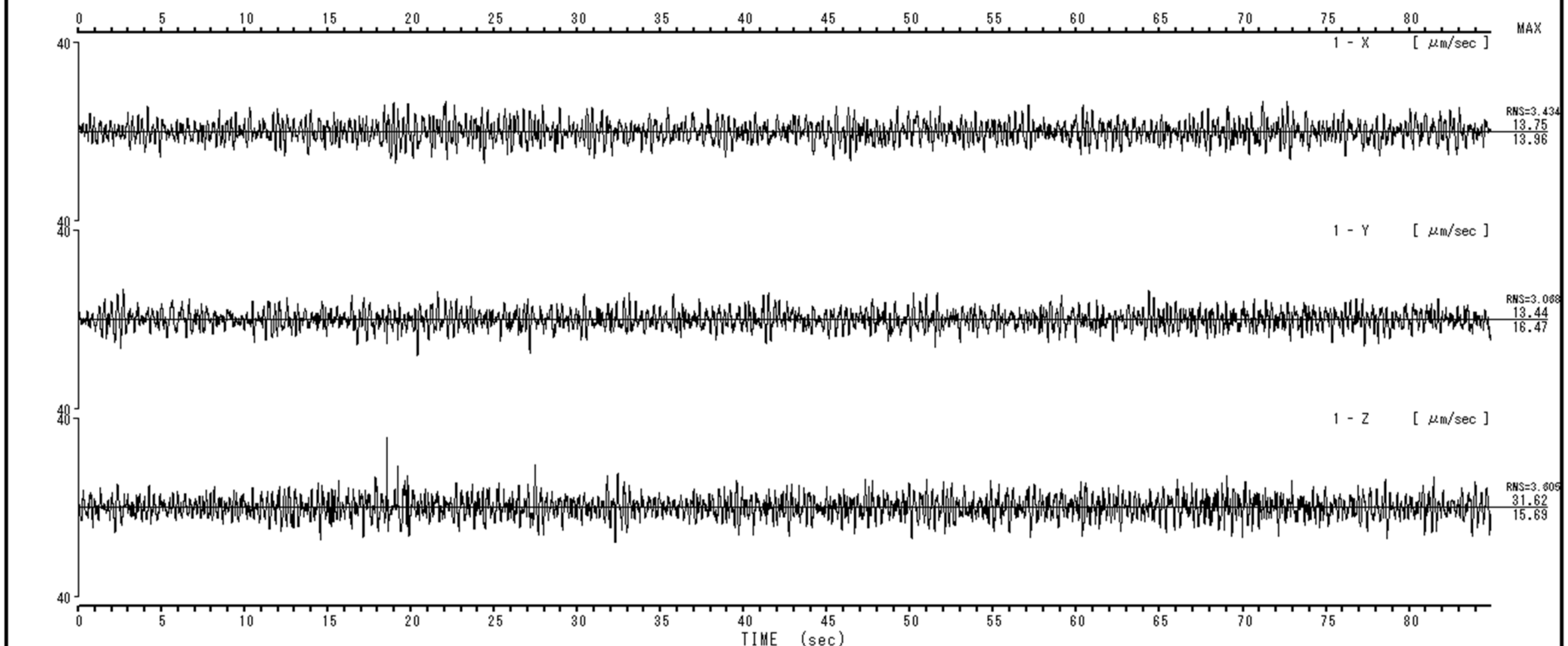
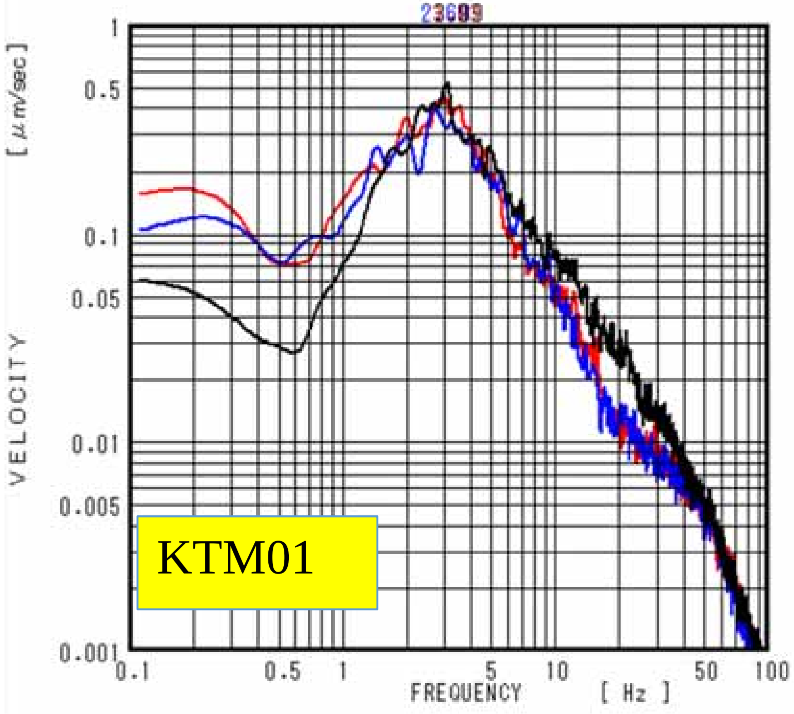


図 - 0	ファイルKTM01. : データ区間 0.005 ～ 84.88 秒

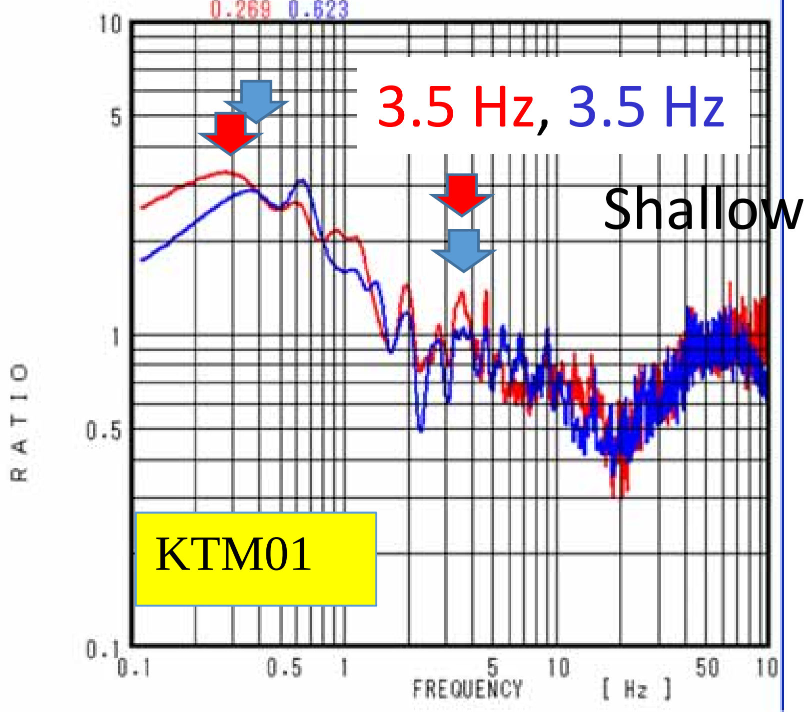
File name: KTM01, Sampling frequency: 200 Hz

Fourier Spectra and Horizontal-to-Vertical Fourier Spectral Ratios from Microtremor Measurement at North Kathmandu

KTM01 27 ° 40.11'N, 085 ° 18.19'E 0.27 Hz, 0.38 Hz=2.6 s, 3.7 s Deep soil



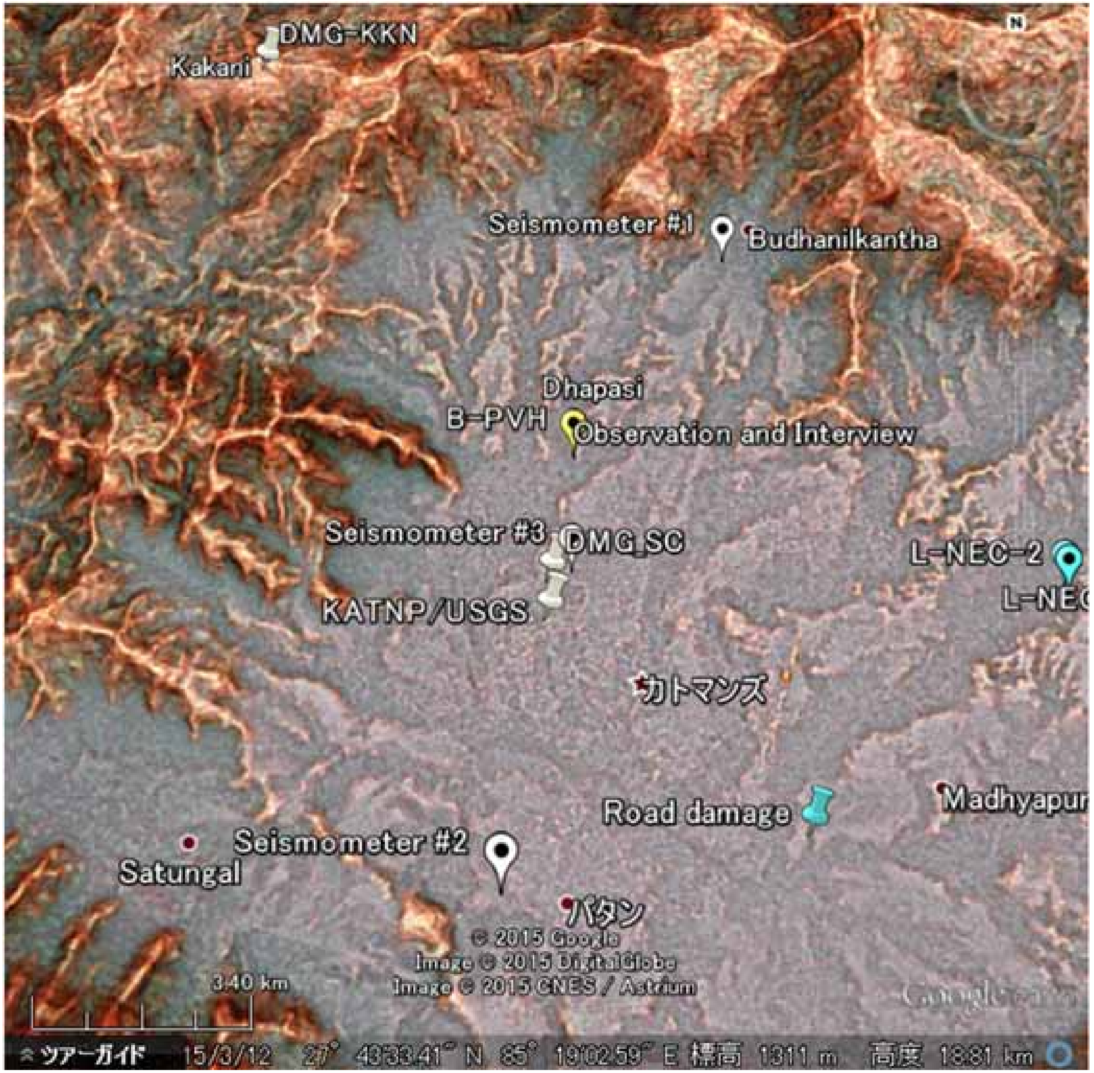
Velocity Fourier spectra



Velocity Fourier spectral ratio

File name: KTM01, Sampling frequency: 200 Hz, Parzen Window: 0.3 Hz

Seismometers in Kathmandu Basin



DMG-Kanini is located on the mountains of base of the basin.

Center of the basin

DMG-National Seismological Centre

USGS-KAT

EU #3

This Red Relief Image Map of Kathmandu based on the technology of ASTER GDEM© with 30-m resolution was prepared by Dr. Tatsuro Chiba of Asia Air Survey Co. Ltd.

This map has been permitted anyone to use freely in the case of investigation or disaster response activity for Nepal Earthquakes

http://gdem.ersdac.jspacesystems.or.jp/faq.jsp

ASTER GDEM

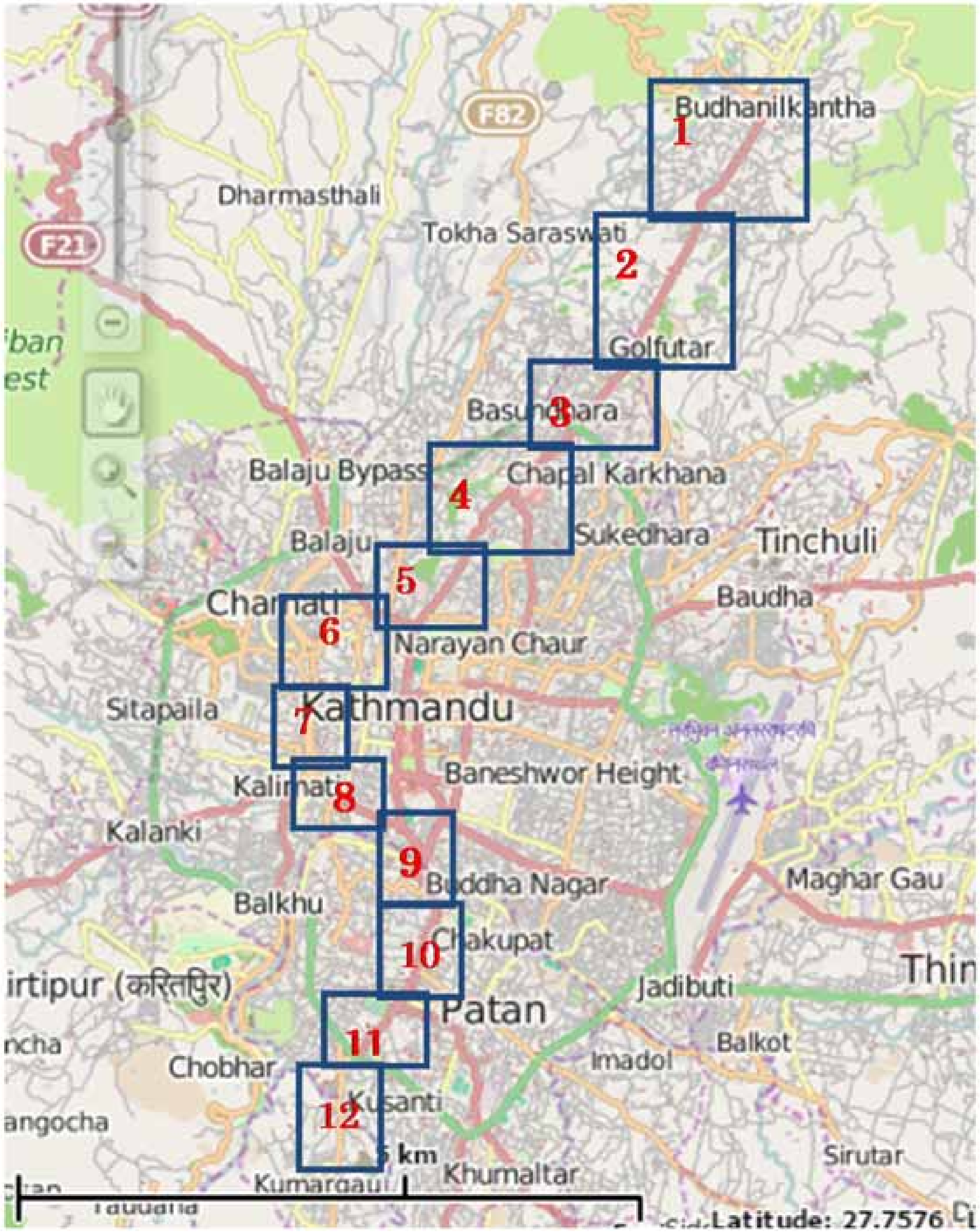
Seismometers in the center of Kathmandu

Center of the basin

DMG-National Seismological Centre

USGS-KAT

EU #3



Damage Assessment on Buildings by Ehime University Team

In order to study correlation between damage ratio and predominant period of ground vibration, our team carried out a kind of partial exhaustive survey along a roughly N-S running street. Eight members were divided to four groups. Each group has a Nepali member for guiding and interviewing.

Rapid Damage Assessment Procedures

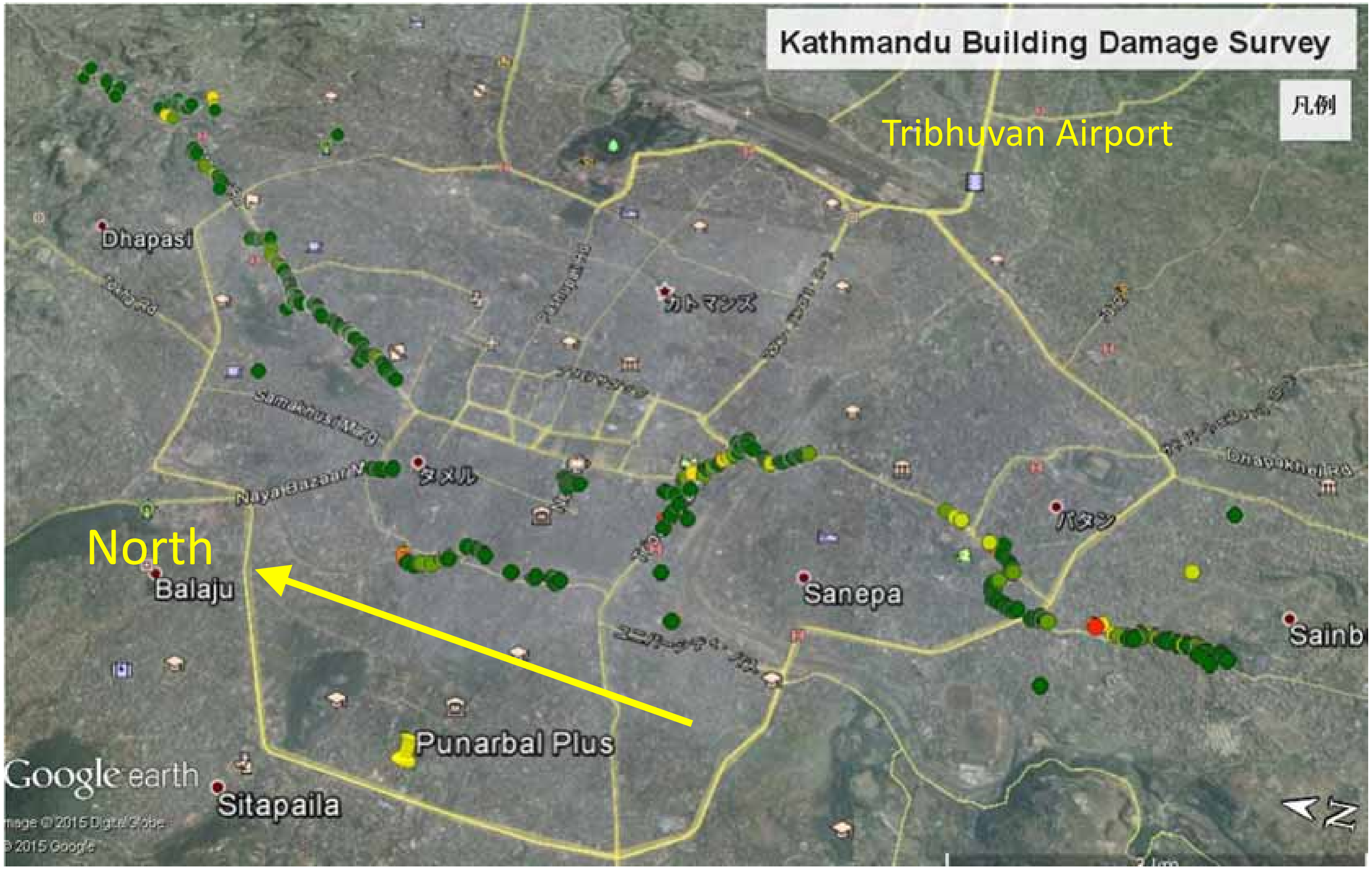
(1) To provide data sheets to members and requested to study

(2) To provide a set of street maps to specify locations

(3) To teach RDA procedures as per EMS-98 standing in front of example buildings in Kathmandu. Ways of taking photos, focusing points on actual buildings with regard to structural/nonstructural elements

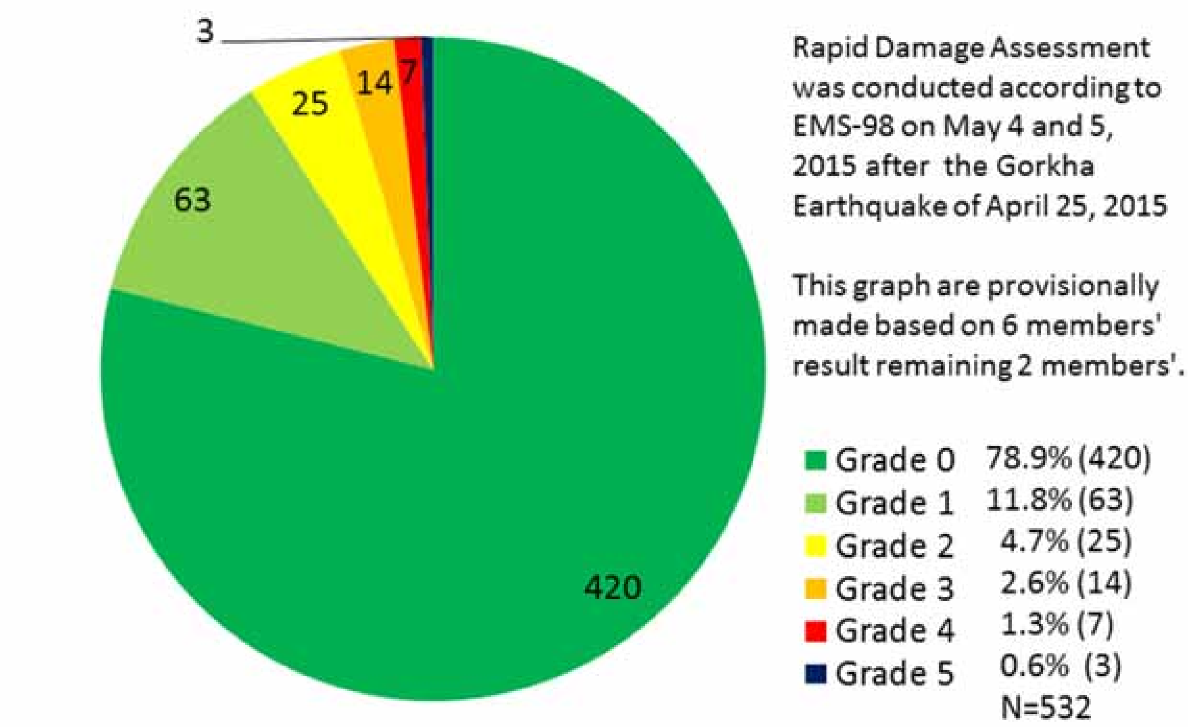
(4) To confirm the appropriateness of assessing each building for unifying the criteria

Provisional Overall View of Rapid Damage Assessment in Kathmandu by Ehime University Team



Along the N-S street. Most classified to Grade 0, 1 and 2. Grade 3, 4, 5 are few.

Provisional Result of Exhaustive Rapid Damage Assessment in Kathmandu by Ehime University Team



Provisional Result of Exhaustive Rapid Damage Assessment on Buildings along continuous North-South main roads across Kathmandu by Ehime University Team, as of May 13, 2015

Along N-S main roads across Kathmandu Municipalities,

No or Slight Damage

(Grade 0 and 1)

90.7 %

Brick work in KTM

13 story high-rise building near Thamel in KTM

No structural damage, slight nonstructural damage (G1)

No damage to engineered buildings in core of KTM

No structural damage, slight nonstructural damage (G0)

No damage to bridges in KTM

No structural damage

No damage to bridges in KTM




No structural damage and affect to bridge abutment was observed.

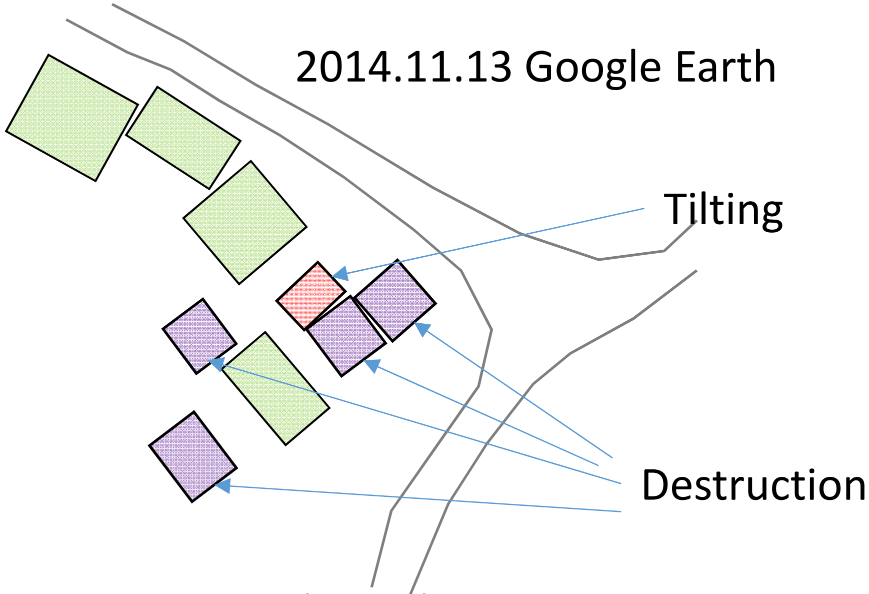
Gongabu, KTM

Gongabu, KTM

Added after seminar

2014.11.13 Google Earth

2015..5.3 Google Earth



A tilting 5-story RCIW building surrounded three destructed buildings in Gongabu. Widely known by media news.

Gangabu, KTM

The first story columns were crushed in the front side and survived in the rear side. Accordingly the building tilted.

Kathmandu (KTM) from the sky

Few damage on the hill in the north of Tribuvan Airport were recognized

Kathmandu (KTM) from the sky

Few damage were recognized.

Kathmandu (KTM) from the sky

Water tanks on the roof, which is vulnerable in earthquake motion are not damaged.

Kathmandu (KTM) from the sky

Few damage were recognized

Kathmandu (KTM) from the sky

Slight damage to chimney was recognized.

Park Horizon, KTM

All the large cracks were on the walls, or non-structural elements. No visible cracks on the structural elements.

Park Horizon, KTM

Normal buildings around the Park Horizon suffered no damage. According to our interview to local people regarding their behavior during the quake, seismic intensity there would have been 4 to 5- in JMA scale, or 7 in MMI scale.

Sankhu

80-90% buildings are reportedly destructed or heavily damaged.

Sankhu

A temple before and after the quake.

Sankhu

A RC build may have helped old masonry buildings against collapse.

An other damage assessment team in Sankhu

I came across a group of French Embassy gentlemen in Sankuh Town by chance! I individually taught them the way to assess damage to a reinforced concrete building in Nepal from the structural engineering point of view because they are laypeople. I have expected they consider my advice. Their assessment was a bit conservative.

Sobhabhagawati, KTM

A RC build may have helped old masonry buildings against collapse.

Sobhabhagawati, KTM

A RC build may have helped old masonry buildings against collapse.

Near Kakhutapur

A RC build may have helped old masonry buildings against collapse.

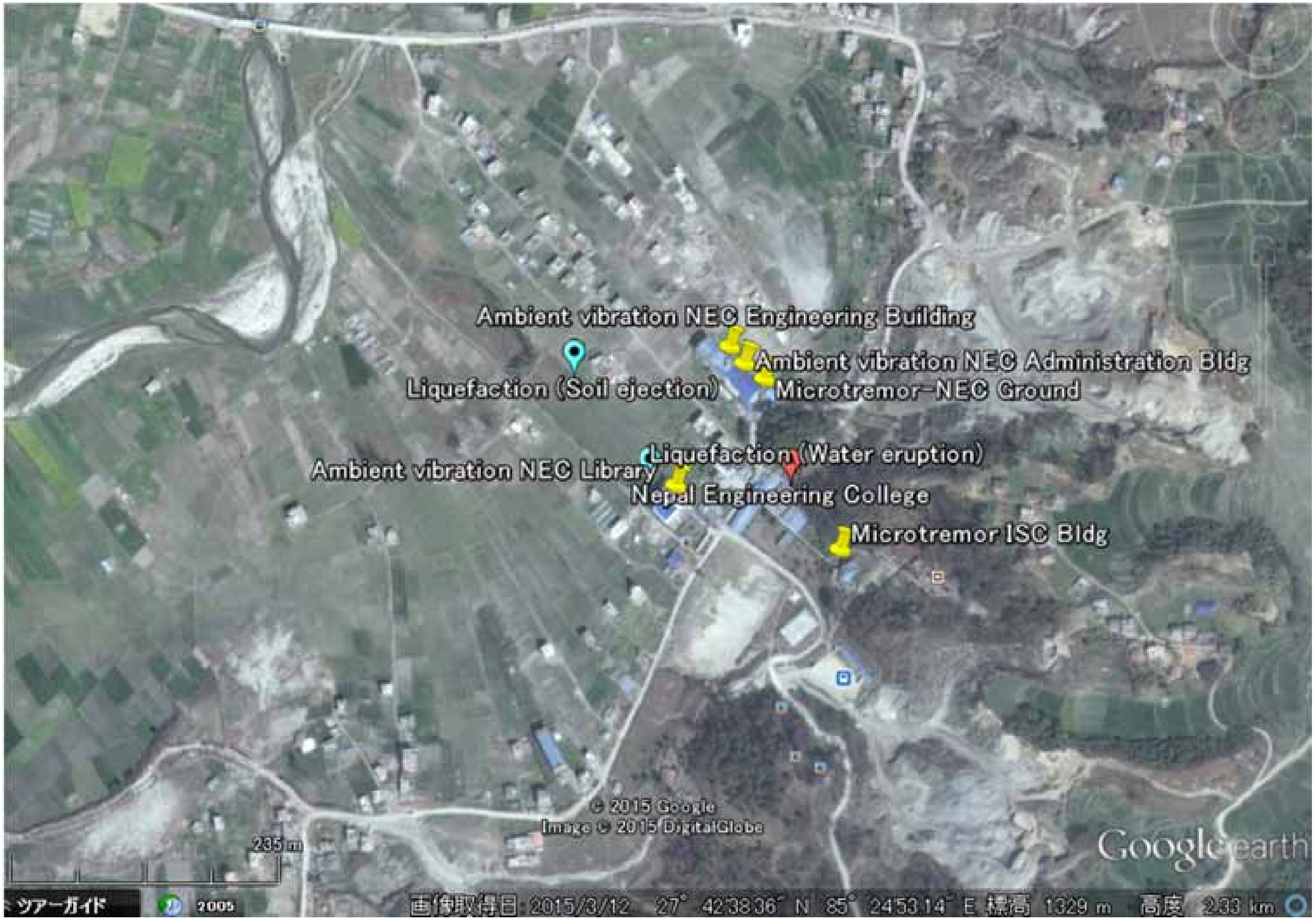
A damaged 5F-building (G1) in Pulchowk, KTM

Damage: Cracks on the nonstructural internal brick walls. Bending cracks at the head of columns of the first story resulting delamination of plaster. Slight damage.

A damaged 5F-building (G1) in Pulchowk, KTM

A damaged 5F-building (G1) in Pulchowk, KTM

Liquefaction and associated damage



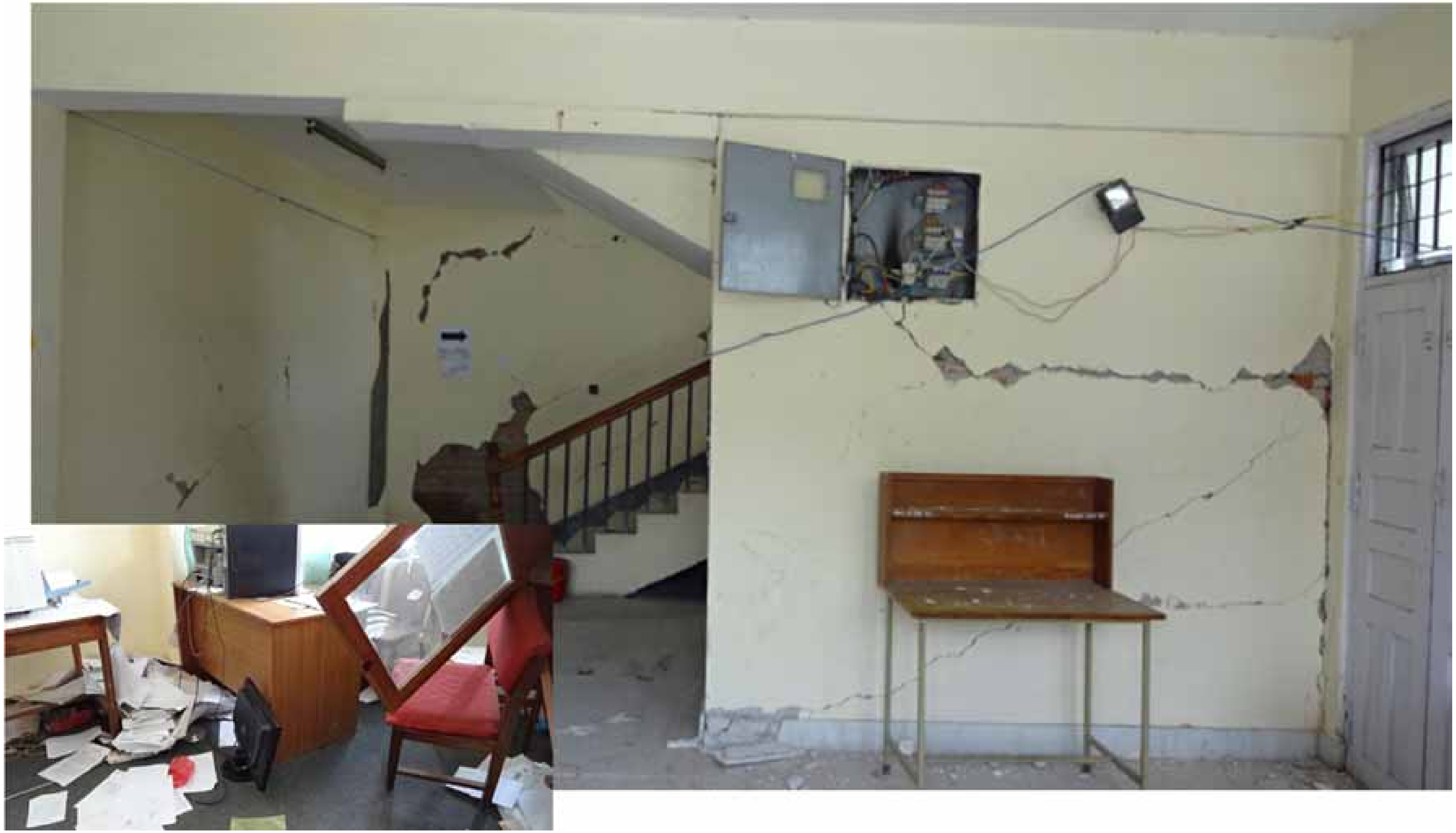
Nepal Engineering College buildings and surrounding houses damaged due to soil liquefaction: Settlement of buildings and houses observed.

Liquefaction and associated damage

27 ° 42'40.01"N, 85 ° 24'50.63"E, Alt. 1326 m

Ejected sand during shaking of main shock from a fissure

Liquefaction and associated damage



Brick shear walls suffered damage (G2). Subjects overturned (0.2g).

Liquefaction and associated damage

Mortar was not good

Liquefaction and associated damage



3 cm settlement relatively to ground and 6 cm another building

Liquefaction and associated damage

Ejected sand during shaking of main shock

Liquefaction and associated damage

Seismic coefficient was estimated to be some 0.2 g.

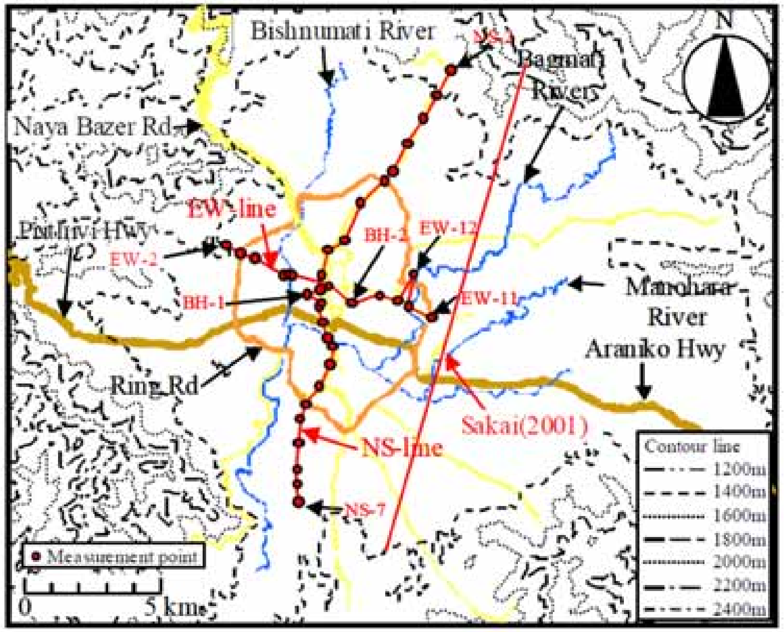
Seismic damage at NEC

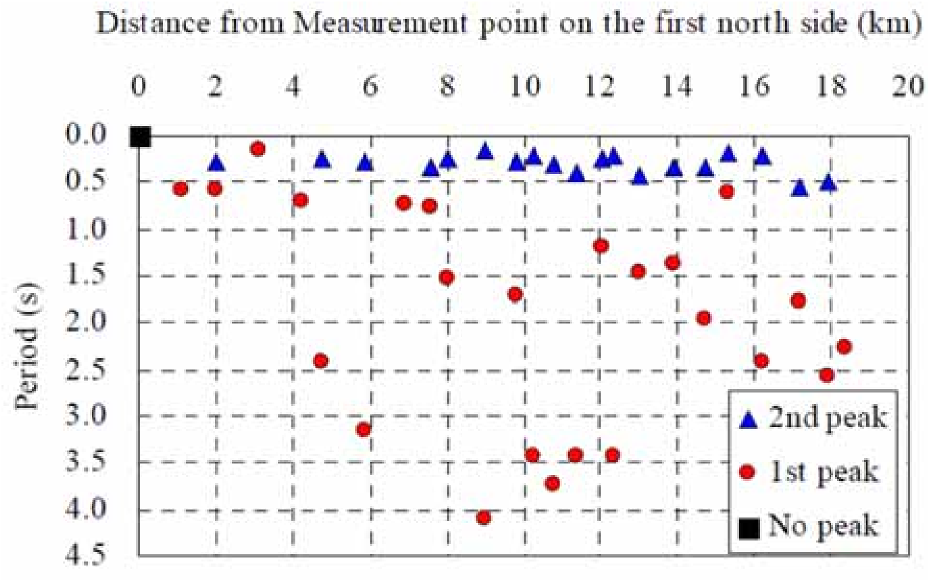
Concrete block wall was completely overturned. Saturday day time.

Liquefaction and associated damage

Parapet walls are damaged due to liquefaction-induced relative settlement.

Microtremor measurements on ground





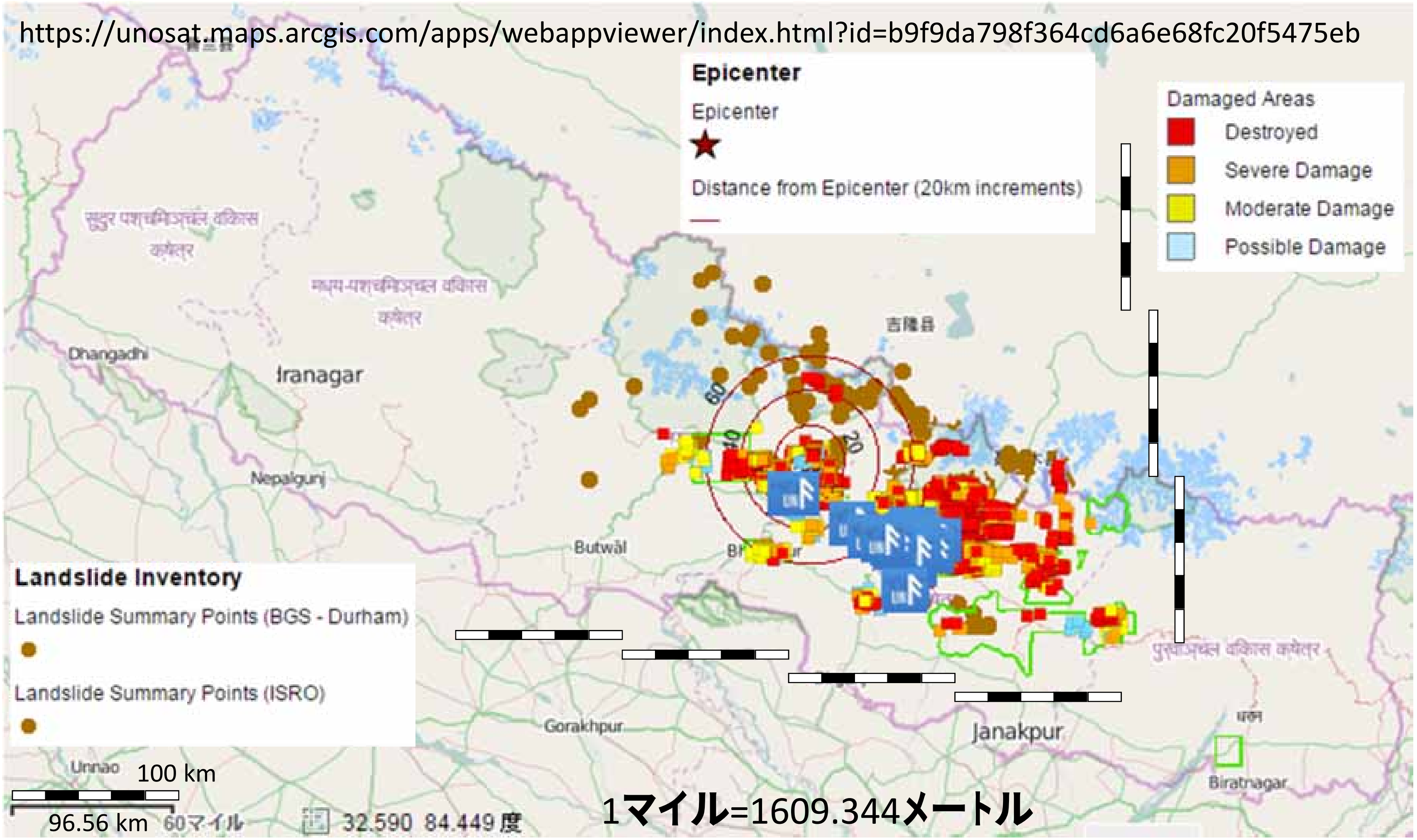
Locations and results of microtremor measurement in 2008 by Mori et al

Existing information of ground motion amplification characteristics in Kathmandu Valley obtained by Mori (Kukidome, Mori, Bhandary, 2009) is a key information for understanding the distribution of damage to buildings and structures there. Referring to this info, it is important to conduct such measurement in several typical damaged areas for reconstruction and rehabilitation after emergent response activity.

Ambient vibrations in Kathmandu, Nepal

Investigation with my student, Deepak in 2008

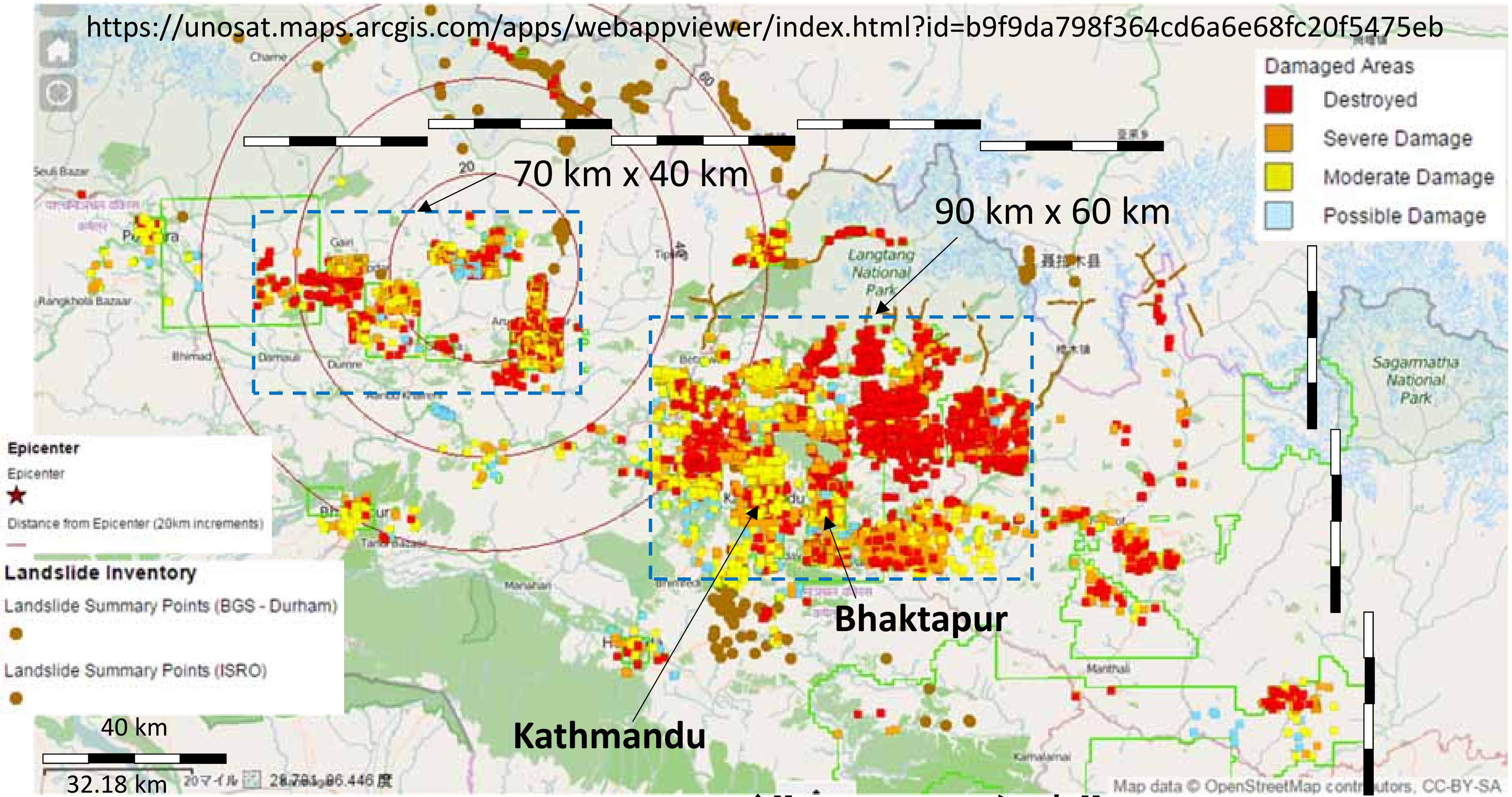
Damage distribution estimated by UNOSAT



Damage to structures: 280 km (East-West) x 160 km (North-South)

Landslides: 280 km (East-West) x 220 km (North-South)

Damage distribution estimated by UNOSAT

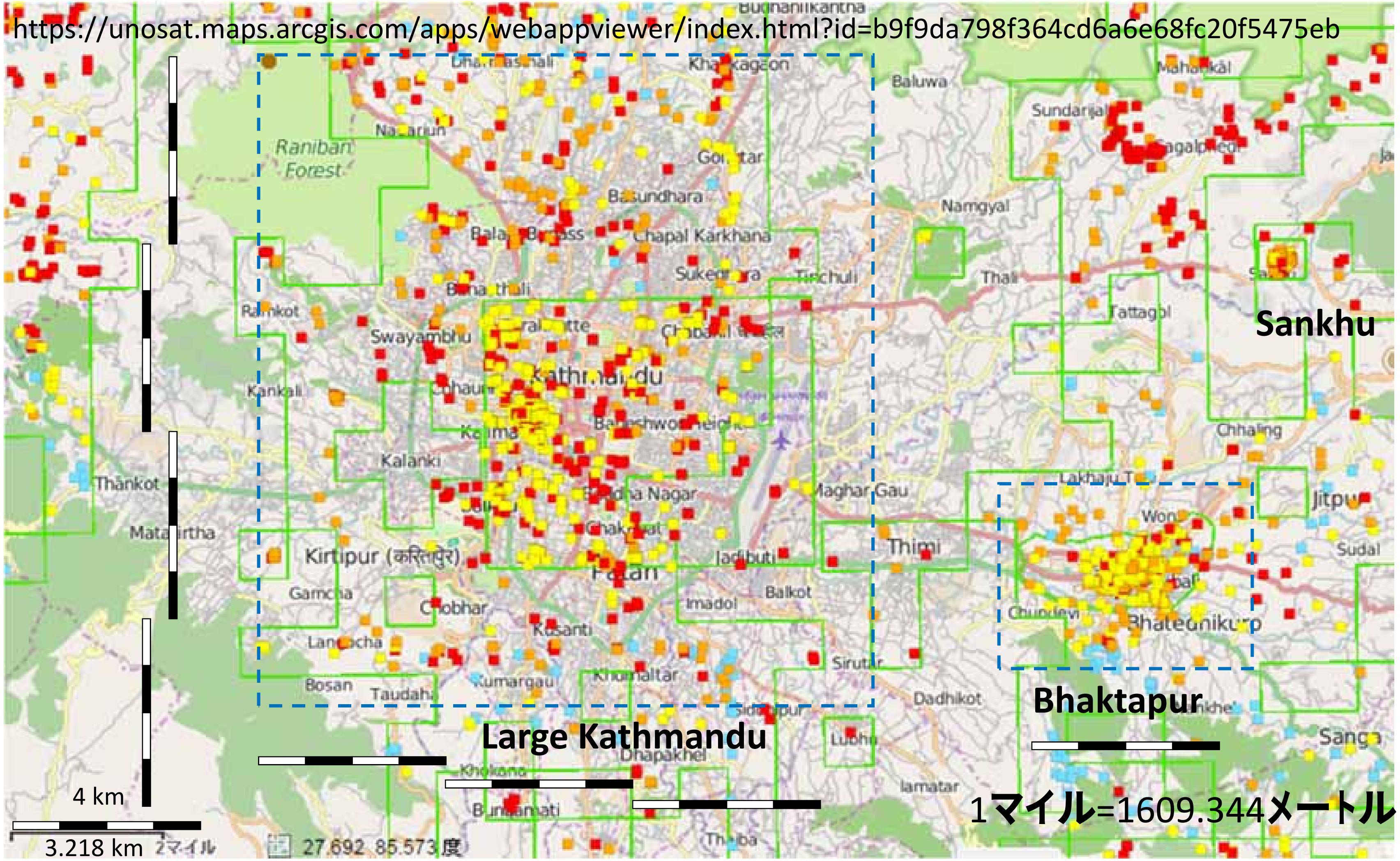


1マイル=1609.344メートル

Intensive Damage Areas: (1) 70 km x 40 km (Epicentral),

(2) 90 km x 60 km (KTM and surroundings)

UNOSAT damage map & our investigated areas

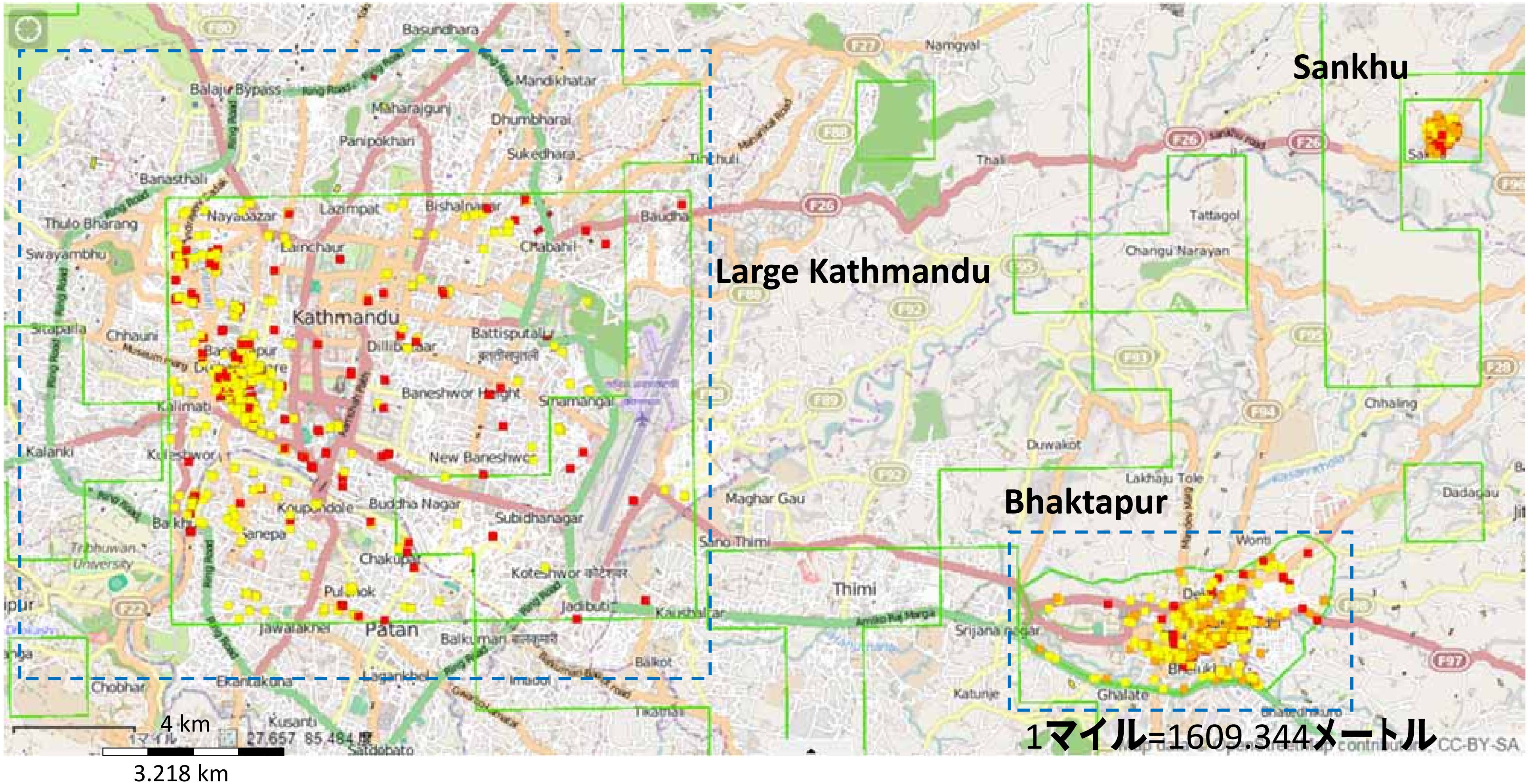


Ehime University Team

Investigated Damage Areas: Kathmandu and surroundings, Bhaktapur, Sankhu

UNOSAT damage map & our investigated areas

https://unosat.maps.arcgis.com/apps/webappviewer/index.html?id=b9f9da798f364cd6a6e68fc20f5475eb



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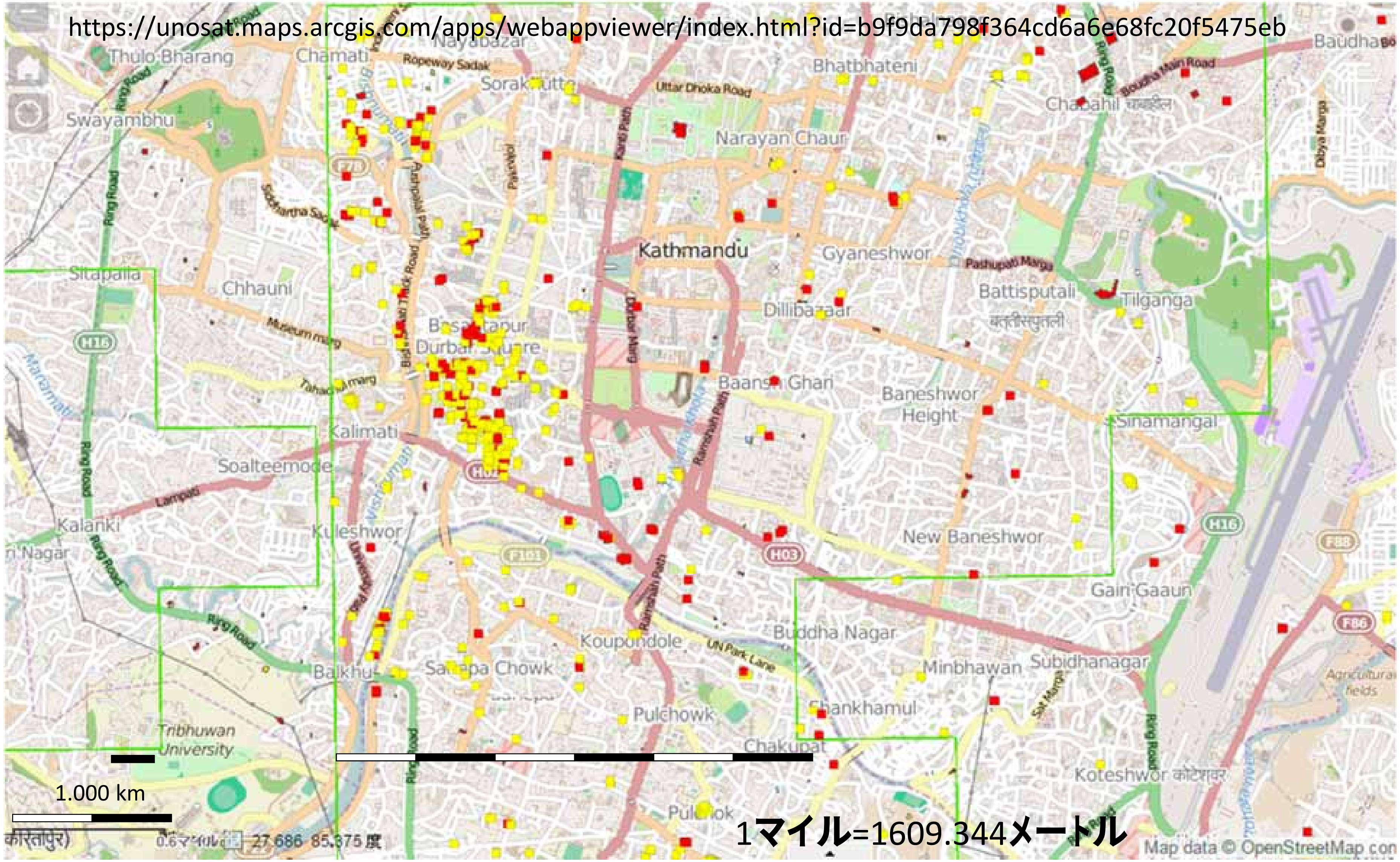

Ehime University Team: Investigated Damage Areas in Kathmandu

Necessary Investigations

Development of damage inventory

Distribution of damage and analysis

Questionnaire survey on seismic intensity for intensity distribution

Microtremor survey in Kathmandu basin and its vicinity for development of ground modeling

Development of strong motion network

Engineer's education for damage assessment and rehabilitation