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AN IMPROVISED SHAKE TABLE FOR RAISING AWARENESS ON SAFER CONSTRUCTION

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SUMMARY

The greatest challenge to the professionals involved in transferring earthquake resistant construction technology to the people is to convince them about its effectiveness. It is necessary to drive home the fact that earthquake resistant components being prescribed really work during actual earthquake shaking, and an earthquake resistant building does not collapse during an earthquake. The need of an effective tool to convince on the usefulness of earthquake resistant construction techniques was more than necessary.

A demonstration tool to compare the effects of seismic shaking on the conventional and an improved earthquake resistant building was conceptualized during the implementation of National Building Code Development Project during 1992-94. The concept was to place a pair of small model buildings and vibrate them on a table-top. One of the models would be built as per the prevailing construction practices and the other would be constructed with seismic resistant components. Both the models would be placed on top of the vibrating table and shaken to simulate the effects of earthquake.

The concept was initially tested by conducting a pilot project in 1996. The success of the first pilot test opened the door for its wider application. The shake table of Nepal has now become one of the best proven tools to make the general public aware about the importance and effectiveness of simple earthquake resistant construction techniques. The process involved in the demonstration also provides an opportunity to train masons on earthquake resistant technology. Subsequent improvement to the shake table demonstrations and its inclusion as a regular event in the Earthquake Safety Day programs of Nepal has proven its usefulness as simple but effective awareness raising tool. So far NSET has implemented several such shake table tests not only in Nepal, but also in different seismic regions of Asia including India and Afganisthan.

INTRODUCTION

Nepal, a small kingdom located in between India and China lies on the central portion of the Great Himalayan Range. The entire length of Nepal sits astride the boundary between Indian and Tibetan tectonic plates. This is the main reason why Nepal has experienced many devastating earthquakes in the

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past and why it will be facing many such events in the future also. The great Bihar Nepal Earthquake of 15 January 1934 was the most devastating event so far: it killed 8519 people and pulled down more than 250 thousand buildings throughout Nepal. During the period of 679 years from 1255 to 1934 AD Nepal experienced ten such devastating earthquakes.

"*1990 Salko Maha Bhukampa*" (The Great Earthquake of Nepal, 1934) written and published by Brahma Shamser Jung Bahadur Rana was the first complete documentation of the devastating earthquake and the response made. This document also provides the then concepts on the seismicity of Nepal and the possible mitigation measures to achieve seismic safety. Unfortunately the recommendations could not be disseminated properly in early days.

Institutional attempts to propagate earthquake resistant construction techniques could be initiated only after the 1988 Udaypur Earthquake, which killed 721 people and destroyed more than 150 thousand buildings in eastern and central Nepal. The National Building Code Development Project, jointly undertaken by His Majesty's Government of Nepal (HMG/N) and UNCHS (habitat) during 1992-94 undertook a detailed seismic hazard mapping and risk assessment for Nepal. The project also drafted the National Building Code for the country with due consideration of the assessed seismic hazard and risks in Nepal.

Thereafter came the challenge to convince the people on the effectiveness of earthquake resistant components in their building and make them believe that an earthquake resistant building would not collapse during earthquake. The challenge is true for most countries in seismic areas. However it is more important for a country like Nepal where more than 95 % of the residential buildings are non-engineered, owner-built dwelling units.

The simplest solution may be to construct an earthquake resistant building and wait until the next earthquake strikes. Survival of the building from the bang will convince the people. But, no one can afford this solution! The need to use an effective tool to disseminate earthquake resistant construction techniques was more than necessary. The improvised shake table provided the solution.

THE CONCEPT

A demonstration to compare the effects of simultaneous seismic vibration on the conventional and earthquake resistant building was conceptualized. The concept consisted in placing small-scale model buildings side by side on a table, vibrating the table and observing the consequence. This required the following components:

- A vibrating table large enough to accommodate at least two models.
- One model building built using the conventional construction practices.
- Another model building constructed with seismic resistant elements.
- Financial and other resources to conduct the test.

THE PILOT TEST

A Pilot Test of the concept was proposed by the author in 1996 while he was working as a Program Leader of Shelter Development Program (SDP) within Development and Consulting Services Butwal, Nepal (DCS, Butwal). DCS Butwal approved a budget of NRs. 75,000 (US $ 1250.00) for the pilot test as per the proposal.

Vibrating Table

A vibrating table was designed and fabricated for the pilot test. The table consisted of two parts: the lower part was a steel frame with spring and necessary attachments that facilitate to induce vibration. The upper part consisted of a steel frame attached with rollers on the lower portion and a 150 cm long 90 cm wide 1.9 cm thick tabletop on the upper side. This table was named "**Kampan Machan**" meaning vibrating table in Nepali language.

Model Buildings

One small existing building with brick masonry walls Bardghat in Rupandehi district of Nepal was selected for the model. Construction materials required for the buildings were fabricated in 1:10 scale bricks 2.3 cm long 1.1 cm wide and 0.55 cm thick bricks made of 1:4 cement sand mortar in the required number to construct the models. Two models of the building were prepared: one was built as per the prevailing construction practices whereas the other was built with the same materials by incorporating seismic resistant components. Both the models had flexible floors resting on timber joists. Corrugated galvanized iron sheet supported by timber roof structure was used for the conventional model. The earthquake resistant model had fire retardant thatch roof covering supported on timber structure.

Similarly a pair of single room models were prepared from 4cm long 2cm wide and 2cm thick solid concrete blocks in 1:10 scale. 1:4 cement sand mortar was used to make the concrete blocks. The model constructed with conventional practice had a cast-in-situ reinforced concrete slab roof. Precast reinforced concrete joists and slabs were used in the model with earthquake resistant construction technology.

The Demonstration

For the first test conventional model was mounted on the shake table. Shaking was provided with steel springs. The effect of each shaking on the model building was clearly recorded. The model started cracking by the shaking induced through displacing the springs by 3 cm. The model building collapsed completely by the jerk induced after displacing the springs by 6 cm.

The second model with seismic resistant construction technology was mounted on the same table and vibration was induced in the same way as done for the previous model. This time the building did not show any deformation even after the springs were displaced by more than 6 cm. The jerks induced by displacing the springs by 8 cm started to crack the model building. This model got partially damaged when it was subjected to a shock created by displacing the springs by 8 cm. The second model could not be damaged even after prolonged shaking. The maximum possible displacement of springs was only 10 cm.

Subsequently the test was done by placing both the test models in the same platform and vibrating them simultaneously. The result was same as before. The model with seismic resistant elements did not suffer any damage while the other collapsed.

The demonstration was done in front of about 50 persons from various walks of life, including masons, building technicians and engineers and men from the street. All the persons present in the live demonstration were happy as the pilot test succeeded very well. The masons involved in building the models could for the first time observe not only the effects of earthquake in buildings but also the importance and effectiveness of simple earthquake resistant components.

"Safe Shelter", a video documentary was prepared based on the demonstration to disseminate the earthquake resistant construction technology. This video documentation was very much successful in raising the awareness on effects of earthquake in buildings including the importance and effectiveness of seismic resistant construction technology for small residential buildings.

PUBLIC DEMONSTRATION

The shake table demonstration was staged again during the first Earthquake Safety Day in 1999. Three sets of models were prepared to capture different building typologies of Kathmandu.

The first public demonstration was made amongst a large audience of more than 250 including the former prime minister, the then minister of Science and Technology and other high ranking officials from the government including foreign delegates. Thus the NSET shake table became one of the major attractions of the earthquake safety exhibitions during the Earthquake Safety Day. The audience clearly observed the vibrating movements and understood the importance of earthquake components in making the improved model stay erect and intact, while the other crumbled down into ruins. Since then the shake table demonstration has become one regular event during Earthquake Safety day. It has also become a part of other earthquake awareness programs. One of such demonstration of the shake table captured the attention of more than 300 distinguished delegates that attended the symposium on the occasion of the Asian Seismological Commission organized by the National society for Earthquake Technology Nepal (NSET) in November 2002 in Kathmandu.

First Public Demonstration

Each and every demonstration events have been proven to be the best method to disseminate the effectiveness of simple earthquake resistant components in construction of even vernacular buildings.

Kampan Machan in India

NSET provided technical assistance to conduct shake table demonstration in India. Upon the request of SEEDS, an NGO from India involved in earthquake reconstruction in affected areas of 2001 Bhuj Earthquake in Gujarat. The first demonstration was done in Bageswor Uttaranchal with stone masonry model buildings. SEEDS conducted second demonstration in Jwalamukhi; Himachal Pradesh after the demonstrated success in Bageswor.

Testing Stone Masonry Models in India

IMPACT IN CREATING AWARENESS

The shake table demonstration creates a direct impact at two levels. The most important influence is the impact on a dozen masons who are already involved in the process as it provides first hand experience on earthquake resistant construction techniques and also demonstrates the cause-effect relation ship of earthquake resistant elements. The second impact is on the larger mass of general public who watch the demonstration.

Training of Masons

One set of test demonstration requires two building models, one built with conventional techniques and the other constructed with earthquake resistant technology. The making of models eventually becomes an on-the-job training for the masons. This is the best form of training as it provides hands on experience at the least possible expenses.

An interesting incident happened during the first public demonstration during the first Earthquake Safety Day in 1999. Ram one of the head masons involved in making the models was so confident in the conventional model built without seismic resistant components. He believed that the shaking would not damage the conventional model building. This was because he was proud of his sincerity in using proper building techniques and also because he never saw any of the buildings he constructed earlier being damaged. During the demonstration, the conventional building collapsed while the earthquake resistant model was not even slightly damaged. He was dumb-founded beyond imagination. His first reaction after the observation was "*Oh my God! I thought I was making strong buildings for my clients. Now I realize that what I built for years were all death traps and not houses! From now onwards I will not make any buildings without earthquake resistant components*."

Raising Awareness for the General Public

The demonstration is effective in making the public believe in using earthquake resistant construction technology. This is because the public not only have a chance to observe the effectiveness of the technology but also they can compare the normal construction practice vis-a-vis and the improved technology. Everything is crystal clear and transparent "Seeing is believing" actually works here. Everybody who observes the demonstration come home fully convinced and confident on the usefulness of the technology. The most common questions that the general public ask immediately after the demonstration are:

- When will be the next earthquake?
- How much additional cost do I need to bear to build an earthquake resistant house?
- Where can I get the trained masons?
- I already have a house. How can I know whether it can survive an earthquake or not; if not, can I do something to strengthen it?

Such questions clearly indicate that they do not have any doubt on the technology. This is definitely a raised level of awareness.

All this benefit comes at the cost of US $ 2000 per test which shows that the cost of training a mason amounts to US $ 100 and the cost of convincing a person on earthquake resistant construction technology is as low as 50 cents.