Early Scientific Investigations on Earthquakes in India:
Influence of Japanese Seismologists on the development of Earthquake resilient construction in North-East India

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Abstract

Early scientific investigations of global seismic phenomena from the late-19th century onwards include the little known, but seminal, scientific studies undertaken and published by pioneering Japanese seismologists on earthquakes in India at the invitation of the Government of the time. Seismologists such as Professor Fusakichi Omori of the Imperial University of Tokyo and his associates Professor T. Nakamura and Dr T. Koyama made important, but largely overlooked contributions, not only to scientific understanding of seismic phenomena in India in the late-19th and early-20th centuries, but also to the development of earthquake-resilient ways of building in the North-Eastern states of Assam and Meghalaya. Reports of the Imperial Earthquake Investigation Committee (Shinsai Yobo Chosakwai Hokoku in the Japanese Language) published in 1897 refer to a resolution of the E.I. Committee 'respecting the proposal of the British Association for international micro-seismic observation', following which detailed, profusely illustrated reports on buildings and engineering structures damaged by the Great Assam Earthquake of June 12th, 1897 were published in 1898 by associates of Professor Omori, Professor T. Nakamura and Dr T. Koyama of Tokyo Imperial University. Professor Omori was later also invited to participate in the scientific investigations of the widespread damage caused by the Great Kangra Earthquake of 1905 and published extensive, illustrated reports in 1907. These reports were considered to be invaluable at the time they were published, not only for seismologists and scientists of the Earthquake Investigation Committee, but also for 'engineers, architects and builders in general, in showing the mistakes and defects to be avoided, and precautions to be taken against earthquake shocks'. The paper is focused on identifying and analysing the influence of these early Japanese seismologists on the development of the 'Assam Type' construction system that was extensively used for construction in North-East India, following the destruction of Shillong by the 1897 Great Earthquake.

Introduction

Professor Fusakichi Omori, a pioneering seismologist and president of the Japanese Imperial Earthquake Investigation Committee is linked today with 'Omori's Decay Law' of 1894, related to understanding of the aftershock sequence of earthquakes (Davison, 1927;Trivedi, 2015;

Guglielmi and Zavyalov, 2018). He is also believed to have been the first to carry out scientific research and experimentation on the effects of earthquakes on buildings and structures by using a shake table in 1898-99 (Bullen, 2008; Dairoku, 1904 p.118).

Less well known are the contributions that Professor Omori and his associates at Tokyo Imperial University, Professor T.Nakamura and Dr T. Koyama, made through their observations, detailed documentationand scientific analysis , and profusely illustrated reports on the effects of the Great Assam Earthquake of 1897 (8.7 on the Richter scale) that devastated large parts of Meghalaya and North-east India (Luttman-Johnson, 1898) followed by scientific investigations by Professor Omori of the damage caused by the Great Kangra Earthquake of 1905 (Szeliga and Bilham, 2017; LaTouche 1905).

These analytical scientific reports, though less well known than those written by R.D. Oldham on the Great Assam Earthquake of 1897 and the Geological Survey of India memoir on the Great Kangra Earthquake by Charles Middlemiss, were nevertheless influential. A number of sources attribute the refinement of traditional, vernacular systems of building using locally available materials into what is now termed as the earthquake resistant ‘Assam Type’ construction consisting of a braced timber frame with infill lightweight ‘Ikra’ or wattle and daub panels, to be an outcome of the advice given by Professor Omori to the colonial British government of India regarding the best method of reconstruction for buildings that had been destroyed by the 1897 earthquake in Shillong (Gait, 1897; Maxwell, 1897).

THE SAN FRANCISCO CALL, SUNDAY, AUGUST 5, 1906

World's Greatest Seismologist Says San Francisco Is Safe.

DR. F. OMORI, professor of seismology in the Imperial University of Tokio, who was sent by the Japanese Government to investigate the recent seismic disturbance here, has finished his researches and investigations and departed yesterday on the Doric for Japan. He arrived here on May 18 and during his stay devoted his entire time studying the country from Chittenden, the southern point where the force began to show its greatest power, north to Point Arena, where the force was continued out into the Pacific. In speaking of his investigations he said: "I have been interested in this work for many years and from my observations I can state that large earthquakes which remove a great unstability in the earth's crust never happen successively at one and the same place."

TOPOGRAPHY PECULIAR.

PROFESSOR OMORI PREDICTS LONG QUIESCENCE.

By F. Omori.

Figure1. Professor Fusakichi Omori: Internet Source

Early Seismological Investigations in Japan

The initial phase of emergence of scientific seismological investigation in Japan is discussed in a publication entitled 'Recent Seismological Investigations in Japan' by Baron Dairoku Kikuchi, Emeritus professor of Mathematics at the Tokyo Imperial University and former president of the Imperial Earthquake Investigation Committee of Japan. This provides fascinating insights into the different aspects of research and enquiries related to the scientific investigation of earthquakes, not only in Japan, but around the globe (Manila, Alaska, Turkestan and also India) during the late 19th and early 20th centuries. According to Baron Dairoku, 'It was quite natural, therefore, that when western science and scientific methods began to be introduced into Japan, they should be applied to the investigation of the seismic phenomena' as between 416 CE and 1867CE, over 2000 eearthquakes had been documented in Japan.(Dairoku Kikuchi, 1904 p.2).

Dairoku mentions that the scientific study of Earthquakes in Japan was first taken up after 1868 by foreign advisors to government departments, such as Prof. Milne, Prof. Grey and Prof. Ewing among others, leading to the establishment of the Seismological Society of Japan in 1880. In 1886, a chair of Seismology was established in the College of Science at Tokyo Imperial University, and Mr. S. Sekiya, the first professor of Seismology was followed by Professor Fusakichi Omori in 1896.

Figure 2. Impact of the 1891 Mino-Owari Earthquake on buildings.: Internet Source

Following the 1891 Mino-Owari Earthquake in Japan, the Imperial Earthquake Investigation Committee was established in 1892. A significant area of research was linked with one of the objectives of the Earthquake Investigation Committee – that related to ‘ reduce the disastrous effects of earthquake shocks to a minimum, by the choice of proper structures, materials, location etc.’. Professor Omori, secretary of the Earthquake Investigation Committee was mentioned as being the most active member of the Committee.

This not only resulted in a number of reports on damage to buildings and structures of the Earthquake Investigation Committee with the Seismological Institute of Tokyo Imperial University, but also stimulated an interest in various experiments in relation to soil characteristics, strength of materials and joints on which no systematic work had been done till this time, as well as ‘earthquake-proof building’.

Experiments were carried out for a better, more scientific understanding of the movement of brick masonry building walls in relation to the quality of the structures, vibrations of chimneys, fracturing and overturning of columns, as well as in relation ‘earthquake-proof wooden construction’, resulting in identification of essential features of earthquake-proof wooden houses that were constructed in Nemuro and Fukagawa. An ‘earthquake-proof’ house was constructed in the University ground, as well as models of a ‘farmer’s cottage’, an ‘ordinary dwelling house’, a ‘public building’ – all intended to illustrate the essential features of construction recommended by the Earthquake Investigation Committee.

It was also considered necessary to ‘devise and improve seismometers and seismographs’ to record and make careful observations of the movements of the earth as the earthquakes are taking place. For better observation of both severe earthquakes as well as ‘very small or slow movements of earth accompanying earthquakes or due to distant earthquakes, of small pulsatory oscillations, and of slow changes of level, Professor Omori devised an improved instrument known as Omori’s Horizontal or Conical Pendulum Seismograph.

These committed efforts resulted in the publication by the Earthquake Investigation Committee in 1895 of a set of construction guidelines that should be observed in the construction of wooden houses in order to make them ‘better able to withstand earthquake shocks’, or to make them earthquake resilient (Dairoku, 1904. P.100)

It was considered that ‘not only that the study of earthquake phenomena was of great practical importance to Japan, but also that organised scientific investigation connected with seismology was a duty that Japan owed to the scientific world’ (Dairoku, 1904. P.3) Other sources also refer to the fact that Professor Omori was engaged in investigations into the effects of destructive, severe earthquakes in India, California, Sicily and Formosa (Bullen, 2008). In this context Dairoku mentions ‘Moreover, now that our improved seismographs show that earthquake waves are propogated to distant parts of the world, international cooperation has become desirable. The British Association for the Advancement of Science has done well in inviting the cooperation of different countries in seismological work ;’ (Dairoku, 1904. P.117). He further goes on to state that Seismology is not merely of theoretical interest, but of great practical importance, and that ‘we have done our best to advance its knowledge, and now that the cooperation of the whole world is in a fair way to be extablished, I trust we shall not be wanting in doing our proper share of the work’.

It is in this context that Professor Omori of the Imperial University of Tokyo and his associates Professor T. Nakamura and Dr T. Koyama undertook detailed observations and analysis of the Great Assam Earthquake of 1897 and of the Great Kangra Earthquake of 1905. These were published as E.I.C. Ho, No 22 – Report on buildings damaged by the great Indian earthquake of 1897, by Professor T. Nakamura and E.I.C. Ho, No.25 – Report on the Engineering structures in Assam, damaged by the great Indian earthquake of 1897 by Dr. T. Koyama. These reports were described by Dairoku as being very valuable ‘not only to the Committee, but to engineers, architects and builders in general, in showing the mistakes and defects to be avoided, and precautions to be taken against earthquake shocks.’

Role of Seismologists from Japan in India – Investigations into the Great Assam Earthquake of 1897 and the Great Kangra Earthquake of 1905

Figure 3. Impact of the 1897 Great Assam Earthquake on buildings in Shillong.: Internet Source C.P.K.Rajendran 2003 and Bilham 2008

The proposal of the Seismological Committee of the British Association for the Advancement of Science for ‘international micro-seismic observation’ resulted in the involvement of Professor Omori and his associates from Tokyo University, Professor Nakamura and Dr Koyama in investigations into the Great Assam Earthquake of 1897 and the Great Kangra Earthquake of 1905.

According to Luttman-Johnson (1898), ‘Professor Omori, a Japanese seismologist, was deputed to Assam to make enquiries into the great Assam earthquake’ and visited Shillong, at that time the capital of the province of Assam. Regarding the aftershocks of the 1897 earthquake in

Shillong, there is a mention that ‘Professor Omori had succeeded in explaining to us that these aftershocks were merely the residual effects of the first big disturbance, subject to definite laws, and had nothing dangerous in their character’ (Gait, 1898).

Later, in the context of the Great Kangra Earthquake of 1905, Professor Omori is termed as ‘the Japanese savant, the great authority on earthquakes, who has come over from Japan to study this big quake’ by Thomas Latouche who hosted him in Calcutta on 26th May, 1905. Latouche also mentions in his letters that Professor Omori had an introduction from the Viceroy, and that he had heard a ‘good deal about him from Mr. Oldham’, and also that Professor Omori had earlier visited after the great Assam earthquake in 1897.

The advice of Professor Omori and his associates, Professor Nakamura and Dr Koyama, regarding improved techniques for construction, based on the 1895 construction guidelines of the E.I.C., is one of the important contributions of seismologists from Japan in India, and influenced the development of the earthquake resilient, hybrid ‘Assam type’ construction in the north-east region of India post-1897. Professor Omori also provided an instrument with low magnification to the Meteorological Department of the Government of India to record severe earthquakes that was installed at Simla , thereby also contributing in the development of seismology in India .

The Great Assam Earthquake of 1897 and the Devastation of Shillong

The North East region of India is identified today according to the Bureau of Indian Standards code as being in the zone of highest intensity, the severe seismic zone V, and the first scientific studies of earthquakes were started in the North-east by T. Oldham following a severe earthquake in 1860. The 1897 Great Assam Earthquake was one of the most severe earthquakes anywhere in the world, and its effects were felt as far as Calcutta and Ahmedabad. What was later to be termed as the Oldham fault, slipped almost 16m, attracting the interest of seismologists worldwide.

Shillong, developed as a hill station, and the capital of Assam province by the British from 1864 onwards with ‘handsome and sustantial’ buildings of stone masonry with lime or mud mortar, and afforested hill slopes with Khasi Pines and Japanese Cedar (Cryptomeria japonica) planted by the British was completely devastated by the force of the 8.7 magnitude earthquake. The collapse of each and every masonry building in Shillong was recorded, and the Government House was ‘converted in a few seconds into a heap of stones’. There was widespread destruction of the many public buildings such as government offices, hospitals, schools, churches, cutcherry, jail, as well as engineering structures such as bridges and acquaducts, documented in the reports by Professor Nakamura and Dr Koyama, and subsequently by R.D. Oldham.


Figure 4. Impact of the 1897 Great Assam Earthquake on All Saints Church in Shillong. Internet Source- C.P.K.Rajendran 2003 and Bilham 2008

The British officers in charge of the earthquake affected areas reported that the severe earthquake had lighlighted the deficiencies and vulnerability of the system followed for the construction of buildings and bridges, coming to the conclusion that 'no stone or brick built houses are capable of withstanding such shocks' and that 'in future they must be constructed of more pliant materials'(Gait, 1898). Ikra or bamboo and reed buildings were also damaged, but plank buildings with a wooden framework, resting on the ground remained intact.

Figure 5. Impact of the 1897 Great Assam Earthquake on buildings in Shillong. Internet Source- Bilham 2008

Reconstruction in Shillong after the Great Assam Earthquake

Most existing research relies heavily on Oldham's account, often overlooking the reports of the Japanese seismologists and the role of the scientific investigations into a more resilient type of construction. The development of what is often termed as the 'Assam type' construction system, a modified and scientifically engineered version of traditional , vernacular wooden frame and infill contruction system was consciously undertaken in the aftermath of the Great Assam Earthquake of 1897, in Shillong. As testified in the Report on the Dhubri earthquake of 1930 published as Memoirs of the Geological Survey of India Vol. 65. 'Since the 1897 disaster, almost all the houses of Shillong have been constructed of light materials (wood, ikra, and bamboo with plaster) on 'earthquake-proof' lines, so that in spite of their location in many cases on steeply sloping hillsides, they were, in the great majority of instances, undamaged'.

Professor Omori and his associates, Professor Nakamura and Dr Koyama undoubtedly made a significant contribution through advising on the introduction of a resilient form of contruction, derived from and informed by the scientific experimentation into earthquake-proof contruction being undertaken at Tokyo Imperial University on masonry and wooden buildings, as well as the 1895 construction guidelines regarding wooden buildings. Professor Omori advised the use of wooden frame houses with light infill panels constructed using wood from the Khasi pine and Cryptomeria japonica trees that had been planted earlier on the surrounding hillsides of Shillong together with locally available materials such as the traditional reeds and bamboo. The British administrators are believed to have respected the advice of the expert sent by the Japanese government, recording his suggestions and incorporating them in the improved, more resilient 'Assam Type' construction system.

Figure 6. Government Building reconstructed after the 1897 Earthquake in Shillong. (Source: Author)

Professor Omori, on the basis of earlier correlation of earthquake related damages in European style masonry and wooden structures suggested the use of lightweight materials for walls and roofs, with flexible connections between the wooden elements at various levels. The Government house in Shillong, a more than a century old building still in use, was rebuilt after 1897 with raised plinth, load bearing timber framework, wall panels consisting of bamboo frames infilled with ikra reed shoots mesh oriented in the vertical direction, plastered from both sides. Roofed with corrugated GI sheets or thick stacks of ikra reed thatch, the 'Assam Type' construction was used for churches, colleges, government offices and houses.   Due to its flexible connections and joinery between various elements – posts, wall panels, roof trusses, roofing elements, this system offers good earthquake resistance and performs well in this earthquake prone region.

Figure 7. Characteristic features of the 'Assam type' construction after the 1897 Earthquake in Shillong. (Source: Author)

Characteristics of different Earthquake Resistant construction types

Figure 8. Earthquake resistant construction type after 1905 in the Kangra area (Source: Author)

Assam type – Earthquake resilient feature

Figure 9. Earthquake resistant 'Assam type' construction system after 1897 in the North-east region as heritage resources.(Image: Author, 2015)

As death, injury and damage are caused mainly by the collapse of buildings during earthquakes, the resilient 'Assam Type' construction system that evolved as a response to the destruction caused by the great Assam earthquake of 1897 remains of great value in the earthquake prone north-east region of India. An outcome of the scientific investigation, experimentation and innovation by pioneering seismologists from Japan such as Professor Omori and his associates, Professor Nakamura and Dr Koyama, the resilient 'Assam Type' construction system has contributed to risk reduction. and mitigation of damage due to earthquakes in north-east India for over a century, but may now itself be at risk of replacement by insensitive, poorly engineered contemporary construction.

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