2012 National Institute for Educational Policy Research, Seminar on Educational Facilities Research

Educational Facilities in Earthquake Countries:

Exchange of Knowledge between New Zealand and Japan

On November 24th, 2011, National Institute for Educational Policy Research in Japan held a public symposium, "The Great East Japan Earthquake and Schools". In the conference, it was introduced that school administration and efforts on educational instruction in the disaster area of Tohoku, as well as examples of measures taken in other countries for the issues caused by earthquakes. Furthermore, we sent out information toward Japan and overseas on enormous efforts and feelings of those people who have involved in education under extremely difficult situations through the conference. Following the conference, NIER will hold a seminar at the standpoint of educational facilities, focusing on measures of earthquake resistance, situations of disaster reconstruction overseas, as well as the realities and issues of schools played roles as evacuation sites.
In the first part, there will be a speech by Kim Shannon, General Manager of Schools Property Infrastructure Group of Ministry of Education in New Zealand, about measures of reconstruction efforts in the wake of the disaster in New Zealand which has lots of earthquakes as Japan and is known therefore as one of the advanced countries on seismic design. In New Zealand, some school facilities were damaged by the earthquake on February 22nd, which occurred 17days before the Great East Japan Earthquake, and reconstruction projects have been in progress since then.
In the second part, Vice-president. Jun Ueno at the Tokyo Metropolitan University will give a speech first about the reality of school used as an evacuation site and the role which these schools played for local communities in the Great East Japan Earthquake. The second speech will be given by Professor. Toshimi Kabeyasawa about damages to school buildings caused by the Great East Japan Earthquake. Both speakers will talk about their topics based on what they have learned through their field investigations.

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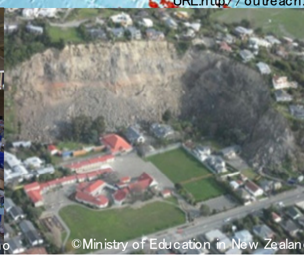

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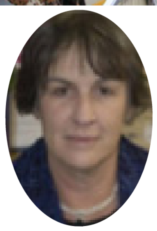

Kim Shannon
General Manager, Schools Property Infrastructure Group, Ministry of Education, New Zealand
Title: Measures of Earthquake Resistance of School Facilities and Reconstruction Efforts in the wake of the Disaster in New Zealand: Current Situation of Earthquake Countermeasures in Advanced Country on Seismic Design

Jun Ueno
Vice-president, Professor, Dr. Engineering, Division of Architecture and Urban Studies, Faculty of Urban Environmental Sciences, Tokyo Metropolitan University, Japan
Title: The Great East Japan Earthquake: Schools as the Emergency Evacuation Site and its Role for the Community

Toshimi Kabeyasawa
Professor, Dr. Engineering, Earthquake Research Institute, The University of Tokyo, Japan
Title: Damages to School Buildings Caused by the Great East Japan Earthquake: Investigation and Post-earthquake Evaluation by Architectural Institute of Japan and Ministry of Education, Culture, Sports, Science and Technology

Report

2012. 1. 24 (Tue)

14:00-17:00 MEXT No.2 Auditorium

Host

NIER
Ministry of Education, Culture, Sports, Science and Technology
NATIONAL INSTITUTE FOR EDUCATIONAL POLICY RESEARCH

Support

Architectural Institute of Japan

2012 National Institute for Educational Policy Research, Seminar on Educational Facilities Research

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Exchange of Knowledge between New Zealand and Japan

2012.1.24 (Tue)

14:00-17:00 MEXT No.2 Auditorium

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FY2011 Seminar on Educational Facilities Research

National Institute for Educational Policy Research

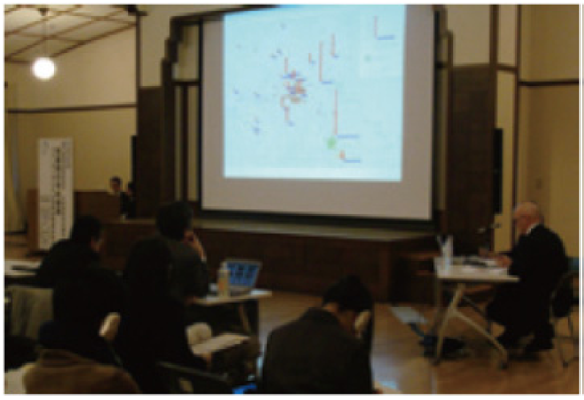
Educational Facilities in Earthquake Countries
- Exchange of Knowledge between New Zealand and Japan -

(14:00 to 17:00 on Tuesday, January 24, 2012, at the No.2 Auditorium, MEXT)

Opening address Tamotsu Tokunaga
Director General of the National Institute for Educational Policy Research

Lecture Kim Shannon
Ministry of Education, New Zealand

Wayne Tacon
Ministry of Education, New Zealand



Kim Shannon + Wayne Tacon

Lecture Jun Ueno
Vice-President of the Tokyo Metropolitan University

Jun Ueno

Lecture　Toshimi Kabeyasawa
Professor of the Earthquake Research Institute of the University of Tokyo

Toshimi Kabeyasawa

Closing address　Fukuei Saito
Director of the Educational Facilities Research Center of the National Institute for Educational Policy Research

Silent prayer

Atmosphere of the venue

Atmosphere of the venue

I. Opening Address

1. Opening

Moderator (Masahiro Kobayashi: National Institute for Educational Policy Research)

Ladies and gentlemen, we would like to begin the FY2011 Seminar on Educational Facilities Research by the National Institute for Educational Policy Research, entitled "Educational Facilities in Earthquake Countries– Exchange of Knowledge between New Zealand and Japan –."

Thank you very much for coming to attend this seminar despite your busy schedules.

I am Masahiro Kobayashi from the Educational Facilities Research Center of the National Institute for Educational Policy Research. It is a great honor for me to be the moderator today.

First of all, upon opening this seminar, I would like to pray for the victims of the latest earthquake and observe a moment of silent prayer. Could you please stand up and join the silent prayer?

Offer a silent prayer.

－Silent prayer－

Thank you very much. Please take your seat.

Let me introduce Mr. Tokunaga, the Director General of the National Institute for Educational Policy Research, the host of today's seminar.

2. Opening Address

Tamotsu Tokunaga
Director General of the National Institute for Educational Policy Research

Good afternoon. I am Tamotsu Tokunaga, Director General of the NIER. It is a pleasure for me to deliver an opening address, representing the host of today's seminar.

First of all, I would like to extend my gratitude to you all for making time in your busy schedules to attend this seminar even though it is a cold day with snowfall.

This is our second seminar concerning earthquakes, following last year's seminar "The Great East Japan Earthquake and Schools: Innovation in School Administration and Educational Instruction."

A big earthquake occurred in the South Island, New Zealand, on February 22, 2011, and on March 11, only 17 days later, another big earthquake hit the Pacific side of the Tohoku region in Japan. I would like to extend my heartfelt condolence to the large number of victims of these two earthquakes. Besides, many other people also suffered damages and were robbed of their property. I would also like to express my sympathies to those who have been struggling to recover from the damage and restore their daily lives.

Since the occurrence of the Great East Japan Earthquake, we have received tremendous encouragement and support from all over the world. Many people have even come to Japan as volunteers to help us. I would like to take this opportunity to express our deepest gratitude to the international community for their kind support.

The Great East Japan Earthquake was an unprecedented disaster for Japan. More than 25 thousand people were killed, missing, or injured, and as many as 0.3 million buildings and houses were completely or half damaged. The amount of damage, limited to that of direct damage on social capital or on residential houses, is estimated to be 16 trillion yen or in other calculations, 25 trillion yen.

Looking at the damages regarding schools from our perspective as persons engaged in educational administration, nearly 900 students and teachers were lost or injured and around 8000 schools were damaged. Of the damaged public schools, around 2000 were severely damaged, needing replacement or major restoration work.

Even under such circumstances, thanks to the warm encouragement and specific support from the international community, as well as from all over Japan, and due to the tireless efforts of local people, devastated areas are now being recovered and restored steadily.

Last year, NIER opened a website for supporting devastated areas as a platform for information exchange with local people, and held an open symposium entitled "The Great East Japan Earthquake and Schools: Innovation in School Administration and Educational Instruction" in November. At the symposium, related people directly introduced their efforts for school management and educational guidance in devastated areas and examples of countermeasures against earthquakes in foreign countries. The information on these efforts being made in extreme difficulties and the feelings of people concerned were transmitted both at home and abroad, evoking various thoughts among many people.

From the perspective of school architecture, this seminar focuses on overseas circumstances concerning earthquake countermeasures and disaster reconstruction efforts, as well as on the present situation and challenges of schools to be used as emergency evacuation sites or shelters.

From the New Zealand Ministry of Education, we have Ms. Kim Shannon, General Manager of the Education School Property Infrastructure Group and Mr. Wayne Tacon, Service Delivery Group Manager. Thank you very much. I hope that we can learn from these two experts' efforts in New Zealand, a country which like Japan is also prone to earthquakes, and has advanced earthquake-resistant technology. From Japan, we have Mr. Jun Ueno, Vice-President of the Tokyo Metropolitan University, and Mr. Toshimi Kabeyasawa, professor of the Earthquake Research Institute of the University of Tokyo. I look forward to their lectures concerning their studies. I am really grateful to have these experts here to attend this seminar despite their busy schedules.

Although the time is limited, I hope that this seminar will serve as a good opportunity for us to learn various countermeasures and studies from experts and to share effective knowledge in reviewing how educational facilities should be constructed in earthquake-prone countries. At the same time, I expect that all of you will take what you learn here back to your workplaces and utilize this knowledge to contribute to the enhancement of the safety and disaster-prevention functions of educational facilities in both countries, as well as to the restoration of areas damaged by the earthquakes. I hope that this seminar will be fruitful and beneficial for all of you. Thank you very much.

(Applause)

Moderator: Thank you very much, Director General Tokunaga.

II. Commemorative Lectures

Commemorative Lectures

Moderator:

Now, we will go on to lectures. Today's seminar consists of three parts. The first lecture is on earthquake-resistant construction of educational facilities and efforts for post-earthquake reconstruction in New Zealand by Ms. Kim Shannon General Manager of the Education School Property Infrastructure Group and Mr. Wayne Tacon, Service Delivery Group Manager of the New Zealand Ministry of Education. Then, after a ten-minute break, Mr. Jun Ueno, Vice-President of the Tokyo Metropolitan University will deliver a lecture on schools as emergency evacuation sites and their roles for local communities after the Great East Japan Earthquake. The last lecture after the next ten-minute break will be by Mr. Toshimi Kabeyasawa, professor of the Earthquake Research Institute of the University of Tokyo, entitled "Damage to School Buildings Caused by the Great East Japan Earthquake –Investigation and Post-Earthquake Evaluation by the Architectural Institute of Japan and the Ministry of Education, Culture, Sports, Science and Technology–."

Please enter your opinions on these lectures freely in the questionnaire sheet at your seat and hand it to the reception staff when you leave the site.

Now, I will introduce you Ms. Kim Shannon and Mr. Wayne Tacon from the New Zealand Ministry of Education. The lecture is entitled "Measures of Earthquake Resistance of School Facilities and Reconstruction Efforts in the Wake of the Disaster in New Zealand – Current Situation of Earthquake Countermeasures in Advanced Country on Seismic Design –."

Please refer to the materials at hand for the profile of today's lecturers. Now, ladies and gentlemen, please welcome Ms. Kim Shannon and Mr. Wayne Tacon.

Lecture

Measures of Earthquake Resistance of School Facilities and Reconstruction Efforts in the wake of the Disaster in New Zealand

- Current Situation of Earthquake Countermeasures in Advanced Country on Seismic Design -

Kim Shannon

General manager, Schools Infrastructure Group, Ministry of Education, New Zealand

Kim Shannon
General Manager, Schools Infrastructure Group, Ministry of Education, New Zealand

Kim's role at the Ministry of Education includes overseeing New Zealand's school property portfolio (which includes around 2,300 school and 8,000 hectares of land, with a replacement value of $16 billion), and advancing new policy initiatives to support greater use of technology in New Zealand schools.

The overarching vision is one of safe and inspiring learning environments for New Zealand students.

In a time of serious fiscal restraint the New Zealand Government remains committed to supporting further investment in 21st century schools. Kim is responsible for implementing a substantial programme of work designed to address issues that include weather-proofing and strengthening school buildings, and respond to changes in demographic growth and distribution. She is also overseeing school property aspects of work underway to renew the education network in Canterbury following the recent earthquakes.

Kim Shannon

(Slide 1) Good afternoon. My name is Kim Shannon. I am the General Manager of the Schools' Infrastructure Group, part of the Ministry of Education in New Zealand. This is my colleague, Wayne Tacon, one of our service delivery group managers.

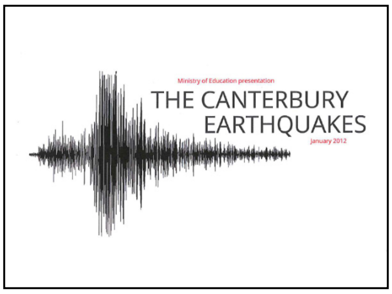
(Slide 2) Before I start, I would like to acknowledge the Japanese disaster of March 11, the Great Tohoku Earthquake and Tsunami and the large of numbers of Japanese people who perished, were injured, made sick, or made homeless by the disaster. This disaster has affected all people in Japan.

(Slide 3) The people of Christchurch and of New Zealand have an understanding of the upheaval that such serious disaster can cause communities. The effects of our own earthquake of February 22 continue to make it difficult to rebuild. But one thing that is shining through is the strength and perseverance of people. We also wish to express our condolences to the families of the Japanese students who died in the February 2011 Christchurch earthquake, and acknowledge the support and efforts of Japan in assisting with the rescue efforts in the city. When I refer to students in my presentation, I am referring to primary and secondary school students in state, state integrated and private schools in New Zealand. This picture shows the iconic Christchurch cathedral after the earthquake.

(Slide 4) In September 2010, the Canterbury region of New Zealand was struck by a magnitude 7.1 earthquake. Two large earthquakes followed, in February and in June 2011, as well as over 9,500 aftershocks.

Today I would like to outline the context in which the Canterbury earthquakes occurred, their impact on school property, and the way forward for the Canterbury region.

(Slide 5) I will also outline the impact of the earthquakes on school buildings and school land, and how the buildings of schools will be approached in the future. This picture shows Halswell Primary School after the September earthquake.



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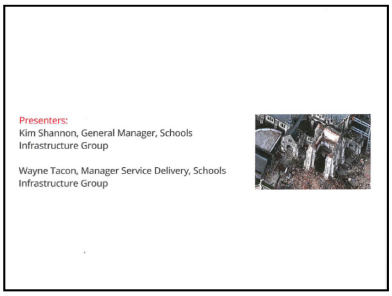

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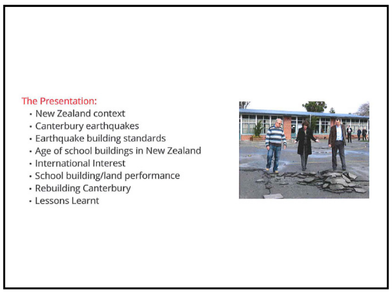

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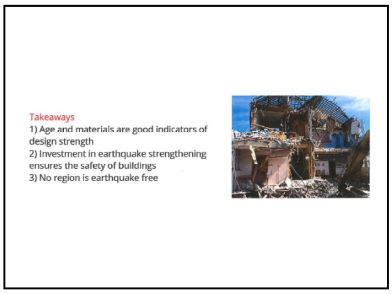


Slide 6

The school classrooms at the back of the picture retained their structure. But inside the classrooms, floors were uneven due to the imperfection. Walls had moved so that doors would not shut. The perimeter walls had moved away from the foundations. This building has now been demolished.

(Slide 6) There are three key observations I would like you to take away from today.

Firstly, the type of materials used in construction, and the age of the building have a direct relation to the damage. Schools in New Zealand are mainly built using masonry, steel, brick, and wood.

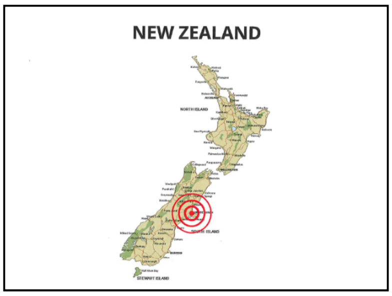
Secondly, the regulatory framework and the resulting design standards meant that the damage from the earthquakes was lessened. Over time, the Ministry of Education has invested in strengthening buildings to meet new standards. Out of 128 schools, at least four will be demolished. The majority of schools had some damage, but can be remediated.

Thirdly, no region is earthquake free. In fact, it was believed before the earthquakes that Christchurch was very low risk with no known fault lines. One point that became obvious in Christchurch was that there was significant damage from ground failure as well as the actual shaking. Much of Christchurch was built near the river and this led to substantial imperfection and damage. Going forward, we will pay more attention to location and soil conditions. This picture shows Avonside Girls' in the process of demolition.

(Slide 7) New Zealand itself situated in the Southwest Pacific Ocean, 3 hours by plane east of Australia. New Zealand is comprised of 2 main islands, the North and the South Island. New Zealand is a multi-cultural country, with a large Asian population. A large proportion of those Japanese residents live in the Christchurch region, the largest city in the South Island. Christchurch has a number of links with other cities around the world, including Kurashiki in Japan. In all, the Canterbury region has 214 schools, 128 in Christchurch City, and approximately 75,000 students.

(Slide 8) As you can see, New Zealand is in an unfavorable geological position both on the ring of fire, and on the juncture between two main tectonic plates. The earthquake in Christchurch was the direct result of the two tectonic plates releasing pressure. When failure occurs in this situation, there is a high-stress drop or significant release of energy.

(Slide 9) This has meant for New Zealand a turbulent history of earthquakes as well as interesting geographical features such as mountain ranges and volcanoes.



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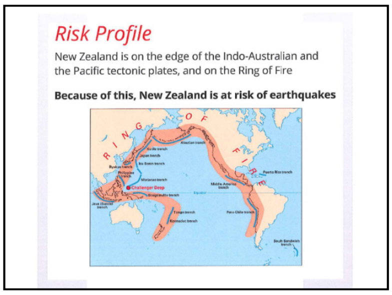

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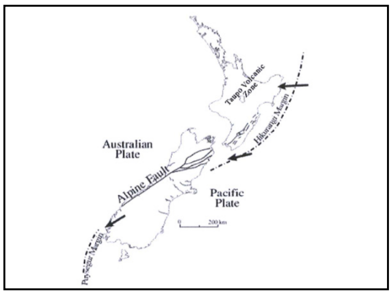


Slide 9

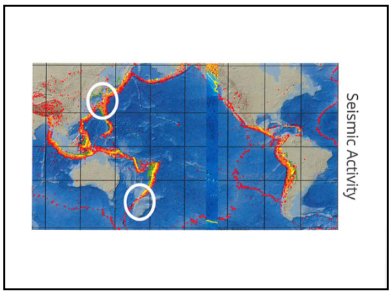
(Slide 10) This picture demonstrates recent seismic activity and shows the respective position of Japan and New Zealand and shows that we face similar challenges and risks.

(Slide 11) New Zealand is no stranger to earthquakes. Throughout our history, there have been a number of powerful earthquakes. This picture shows ten years of shallow earthquakes in New Zealand. We have one magnitude 4 earthquake per day, two magnitude 5 earthquakes per month, two magnitude 6 earthquakes per year, and one magnitude 7 earthquake every three years, one magnitude 8-plus per century.

(Slide 12) The largest earthquake since European colonization occurred in Wellington in 1855. 150km of fault line ruptured, causing an 18m rise, the largest observed on a strike-slip fault. There was also a vertical offset of 6m. It also generated a 10m tsunami. Wellington experienced severe shaking. But the resulting damage was reduced as the city had been extensively rebuilt following the 1848 Marlborough earthquake using mainly wooden structures. Only one person is known to have died. This slide shows Wellington prior to the earthquake and then the effect of the earthquake.

(Slide 13) There have been a number of significant earthquakes since then throughout New Zealand including a magnitude 7.8 in Murchison in 1929 which caused 17 deaths. These early pictures taken at the time show the impact of early buildings from earthquake damage.

(Slide 14) We also had a magnitude 7.9 in the Hawkes Bay region in 1931 which caused 256 deaths. The Napier earthquake was 20km deep, and 2,000 people were injured. The earthquake lasted for 150 seconds. New Zealand has been, for the most part, fortunate to escape serious fatalities in major earthquakes. New Zealand has a sparse population, and few people live in active mountainous regions. The impact of this earthquake meant Napier City had to be rebuilt. The earthquake resulted in a complete overhaul of building standards in New Zealand.



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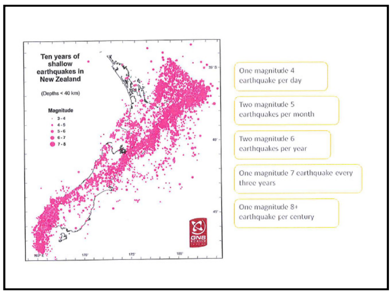

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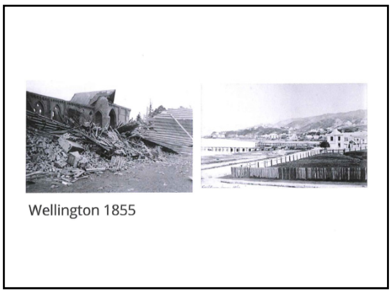

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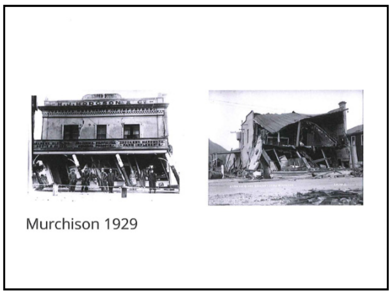

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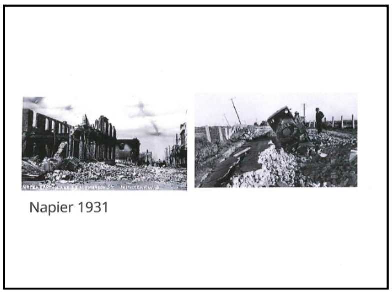

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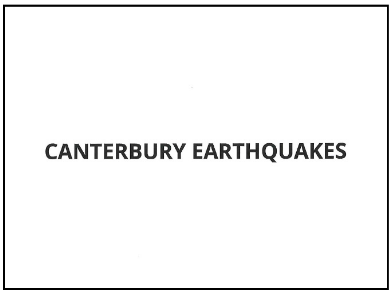


Slide 15

(Slide 15) The Canterbury earthquakes

(Slide 16) on 4th of September 2010, the Canterbury region was struck with a magnitude 7.1 earthquake at 4:35 in the morning. Only two schools were barely damaged, but there were injuries. This was mainly due to the timing of the earthquake, and its remote epicenter.

(Slide 17) This graph shows a vertical and horizontal acceleration in the area. This earthquake was notable due to the large peak ground acceleration (PGA). Note the epicenter, the green star, is far away from the central business district. Note the vertical acceleration closer to the epicenter.

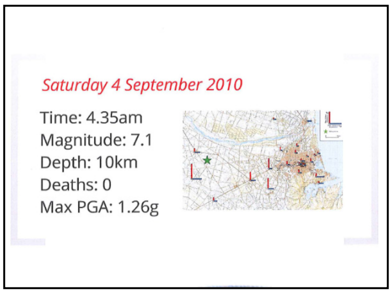
(Slide 18) Six months later the region was hit again with another earthquake. It was only a magnitude 6.3, but it hit at 12:51 p.m., after lunch when people were at work or at school. 181 people lost their lives and there were many, many injuries.

(Slide 19) The density of the shock was significant. The epicenter was close to the central business district and the CBD suffered the most building collapses. The earthquake was only 5km deep, compared to the Japanese earthquake at 32km deep. However, it only lasted for 30 seconds. Please note the extremely high peak ground acceleration.

(Slide 20) Two buildings suffered a significant collapse: the Pyne Gould building and the CTV building, both in the central building district.

(Slide 21) The in-depth report into why the Pyne Gould building collapsed is provided as a Web link. The two main reasons for the collapse were the shaking experienced in the east-west direction was almost certainly several times more intense than the capacity of the structure to resist it. Secondly, the connections between the floors and the shear core, and between the perimeter beams and columns, were not capable of taking the distortions associated with the core collapse. In other words, the design of the building was not sufficient to withstand the force of the earthquake.

(Slide 22) The report into the CTV building will be released early this year,



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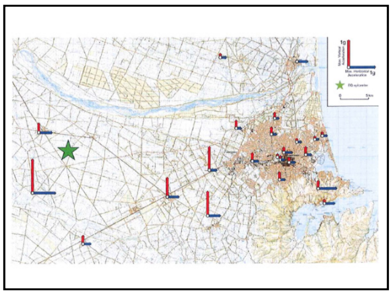
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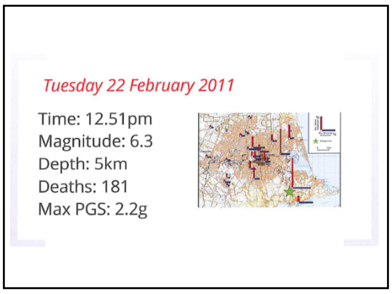

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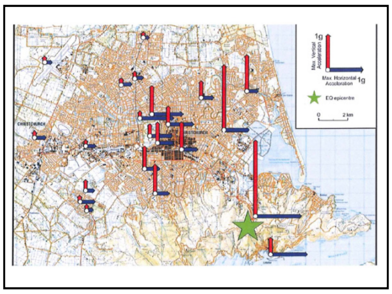

Slide 19

Slide 20


Slide 21

and will be available on the Department of Building and Housing's website.

(Slide 23) Just to emphasize the force of the earthquake, this table shows three major Christchurch earthquakes in comparison with other major earthquakes around the world. Notable is the peak ground acceleration for the February earthquake, up to 2.2g's. The ground acceleration experienced in New Zealand was extreme and is prompting a review of all our design standards. There are a number of reasons why New Zealand did not suffer even greater losses in these earthquakes. Very briefly, low population density, there was no tsunami, the buildings were, for the most part, built to withstand earthquake damage because of New Zealand's stringent earthquake standards.

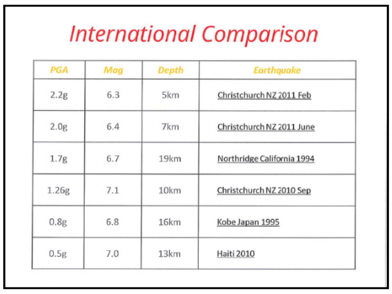
(Slide 24) I will now briefly outline the history of our Structural Design Standards. As with many British colonies, early building standards were decided at local level. Each local authority had their own bylaws and enforced them.

(Slide 25) The Napier disaster in 1931 led to a review of construction standards and the publication of new Building Bylaws specifying the basic loads to be used in the design of buildings.

This was however at the discretion of local authorities and therefore not a national building design standard.

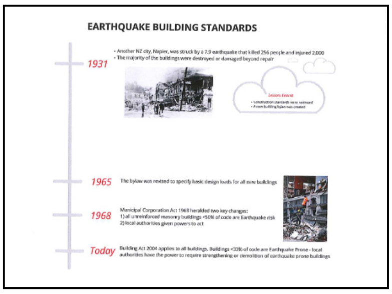
(Slide 26) The revision of the Building Bylaw in 1965, led to the formation of the New Zealand Standard. Importantly, it specified information about the basic design loads expected for all new buildings. This was the called NS 1900. The bill also identified three different earthquake zones in New Zealand, and different standards were set for each earthquake zone. In 1968 a new act signaled two key changes. Firstly, earthquake-prone buildings were identified as buildings that fail to meet 50% of the load specified for new buildings. Secondly, local authorities were given powers to identify and require action on earthquake-prone buildings. In 2004 the Building Act lifted again the expectations of buildings.


Slide 22


International Comparison

PGA	Mag	Depth	Earthquake
2.2g	6.3	5km	Christchurch NZ 2011 Feb
2.0g	6.4	7km	Christchurch NZ 2011 June
1.7g	6.7	19km	Northridge California 1994
1.26g	7.1	10km	Christchurch NZ 2010 Sep
0.8g	6.8	16km	Kobe Japan 1995
0.5g	7.0	13km	Haiti 2010

Slide 23



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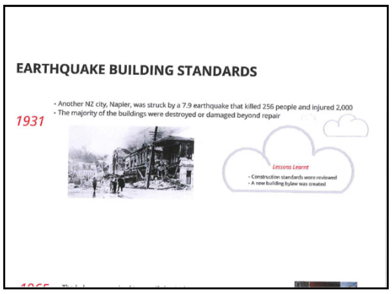

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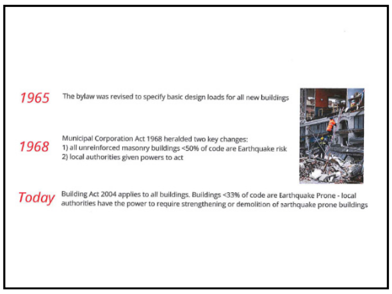

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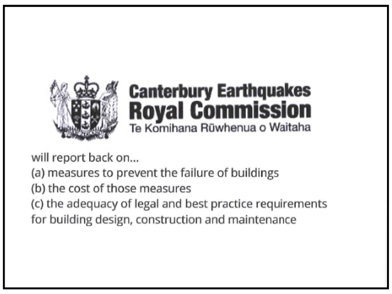
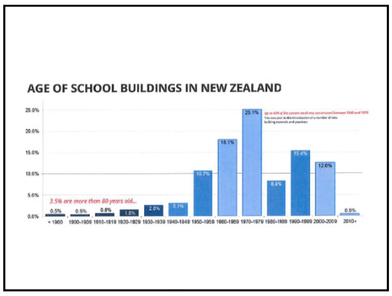


Slide 27

These new standards mean all existing buildings need to be at least 34% of these new Building Standards. (Slide 27) A royal commission will review the current loadings and will also review the timeframes by which council must ensure existing buildings are strengthened. I recommend to each one of you here today that you read the interim report which has already identified seven specific areas where there are problems with building design. The first one is the maximum considered earthquake design; the second is elongation and reinforced concrete; thirdly, the performance of structural walls; fourthly, performance of stairwells; fifthly, the significance of vertical acceleration on seismic performance; sixth, the behavior of structural walls and beams; and seventh, the mesh reinforcement in existing buildings. The royal commission has identified that these seven areas need urgent review in our design standards.

(Slide 28) What are the implications of the evolution of earthquake standards for the school property portfolio? The earthquakes in Canterbury in 2010 and 2011 have provided the first real challenge to New Zealand schools since the 1931 Napier earthquake. This has been a test for both emergency procedures and for the building design standards.
(Slide 29) This chart shows the age of our school buildings.
(Slide 30) 3.5% of our school buildings were built prior to 1930. They are more than 80 years old.
(Slide 31) Up to 43% of the current stock was constructed between 1960 and 1979. This was immediately prior to the introduction of a number of new building materials and practices.
(Slide 32) 63% of our buildings were built before 1980. And buildings constructed before 1935 have been designed in the absence of any earthquake-protective design standards and using a range of materials that are no longer used or recommended. So we have a challenge in terms of our building stock.
(Slide 33) This slide shows the changes in materials and practices over the last 100 years.

Slide 28



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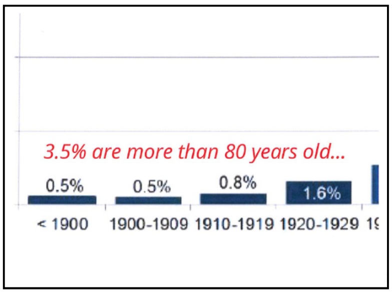

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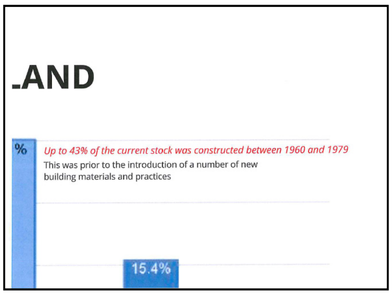

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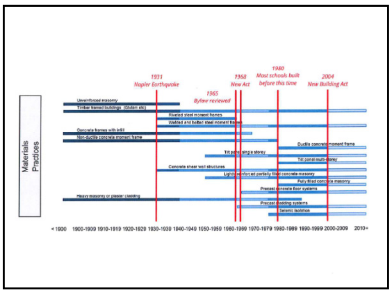
Slide 33

As you can see, there have been significant changes to design codes and to the materials used in the buildings over time. As new materials and construction methods have become available, they have been incorporated into the standards.

(Slide 34) The following few slides show some of our schools, and the periods they represent. Wellington East Girls' College in Wellington is an old masonry school built in the 1920s. The main block has recently been found to be severely earthquake prone and has been evacuated.

(Slide 35) This slide shows what our buildings built in the 1970s look like. This is an example of the state integrated Roman Catholic College at the bottom of the South Island, normally made of brick and two to three stories high. The building on the right is the chapel, typical of this era.

(Slide 36) Finally, this is one of our newest schools, Papamoa College in Auckland. Note the large glass walls, the one-line, open-plan, multi-story design.

(Slide 37) So we have a diverse range of stock. Given the age of our property and the more stringent design standards, the Ministry of Education has invested heavily in seismic strengthening. Over the last 30 years, the Ministry has focused attention on identifying buildings of masonry construction and multi-story height for strengthening work.

(Slide 38) Today, in a new program of remediation, we are reviewing all buildings based on age and materials. The new requirements mean that there may be instances where there is no economic benefit in remediating existing buildings. At the moment we have identified that a third of our buildings require priority attention.

(Slide 39) Investments in seismic strengthening

(Slide 40) In the Canterbury region we have 170 state schools which the Ministry own. While the buildings and property of state schools is government owned, the decision-making on property developments is placed with the local board of trustees. The Ministry-conducted, seismic strengthening program has relied on convincing schools of the importance of this work. Given that prior to 2010, the last major earthquake was in 1931, the imperative to strengthen immediately has not been strong.

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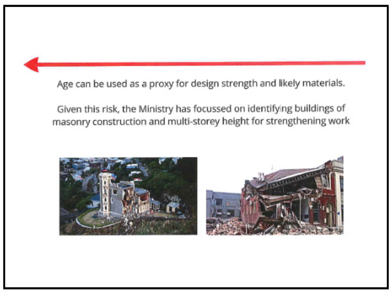

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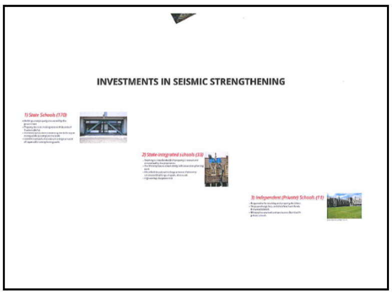


Slide 39

Once school boards have agreed to participate in the seismic strengthening program, buildings are assessed, proposed engineering approaches are discussed and remedial work is structured preferably around the school holiday break.

(Slide 41) The majority of seismic strengthening work has focused on steel reinforcing and bracing solutions such as in this picture.

(Slide 42) Though the teaching at state-integrated schools is government-funded, the property is managed and maintained by non-government proprietors. This means that the Ministry has no direct ability to financially support seismic strengthening in these schools.

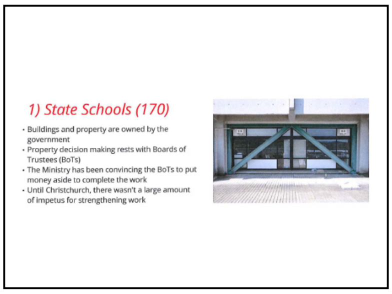
(Slide 43) There are also 11 private schools in Christchurch, and they are owned and maintained by private owners. The Ministry is not responsible for non-government owned property.

(Slide 44) However, the government took responsibility for all schools in the Christchurch earthquake to ensure they were opened as quickly as possible and took responsibility for assisting with infrastructure such as sewage and water. The government also undertook an overarching responsibility to ensure all students were able to access a school.

(Slide 45) So how did our schools perform in Christchurch?

(Slide 46) This is an example of the types of damage of both shaking and ground failure. This is an integrated school. It retained its structure but had to be demolished because it was not structurally sound. You can see an example of foundation collapse where one part of the building has sunken to the ground. Lateral spread damage meant that buildings were damaged in the joining between a new and an old part of the building. Cracking appeared in the ground and liquefaction occurred outside the building and under floor boards. This building and other buildings at this school all had to be demolished because the cracks went through all buildings.

(Slide 47) There were two types of damage in Christchurch, from ground shaking and ground failure.



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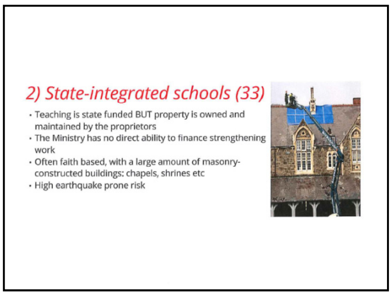

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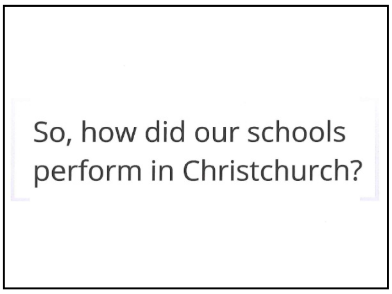

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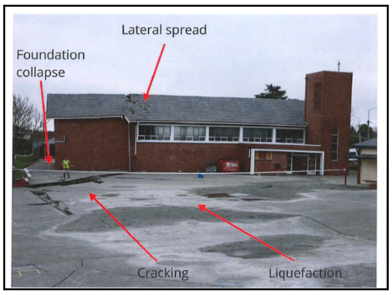
(Slide 48) There was significant damage from ground shaking. Shearing where buildings join together, ground subsided, e.g. foundations, roofs and chimneys collapsed, and many of our injuries were caused by chimneys and parapets collapsing. And bricks and mortar split as in this slide. Many of our brick buildings had these zigzags through them from the effect of shaking.

(Slide 49) The second main cause damage was ground failure. Liquefaction has been extremely damaging for school buildings. It weakens the ground and causes the spreading of foundations. A number of schools across the region were inflicted with liquefaction given that Christchurch is built around a very large river and a swamp. Shirley Boys' High, this school, was our worst afflicted school. On the left you can see liquefaction seeping into the gymnasium. This school is not currently in full use. It is yet to be decided whether the school or school location will be used again in the future. Every time we have a major aftershock, more liquefaction occurs.

(Slide 50) We also had cracks and fissures in the North Christchurch region. There are 3 schools in this area. Fortunately, none were badly affected. This is a young student standing in the crack to show how deep it is. Avonside Girls' High school is situated right on the river, and was the worse damaged school in Canterbury. The school was immediately evacuated and recently demolished. This is a picture of the building not as a result of the earthquake damage but the demolition.

(Slide 51) Landslides and rock fall also caused damage. This was most notable in the large 13, June 2011 aftershock magnitude of 6.3. This aftershock caused large sections of cliff to collapse at Redcliffs, endangering the school below. So the school is at the base of that cliff. So that's the school. Given the risk of more rock fall occurring, the school was evacuated and is now being housed in temporary accommodation. The cliff behind the school is unstable. All the residential houses on that cliff have been evacuated. Nobody lives there now.



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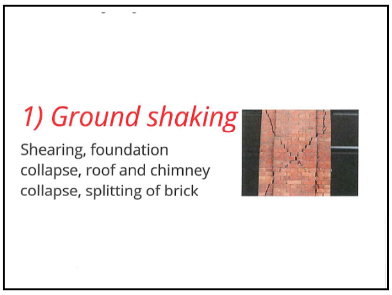

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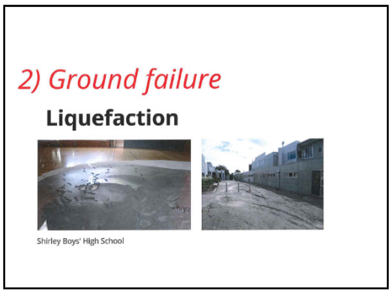

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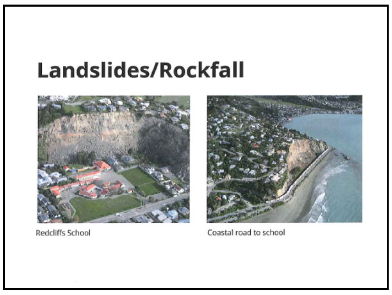


Slide 51

It has large cracks in it, and it is unlikely that the school will be built in the same spot.

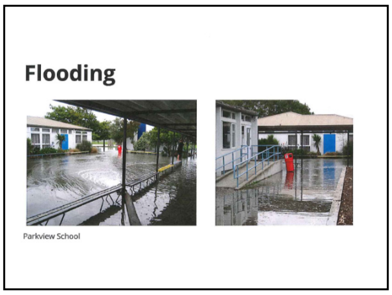
Note in the second picture the line on the right picture is containers, shipping containers, to hold back rocks from going onto the road. The most recent earthquakes a month ago, 23rd of December, resulted in further rock falls and cliff collapse. This is a very unstable part of Christchurch.

(Slide 52) Another impact was flooding. There was a large amount of damage caused by broken pipes, water pipes, and artesian wells.

(Slide 53) This table shows our initial damage assessment. Engineers identified three levels of damage. The majority of our schools had superficial damage including minor cracking. A larger category had some structural issues but mainly non-structural damage. The smallest number of our schools, 29, had structural collapse, failed infrastructure, heavy subsidence, significant damage. At this stage only four of these schools are likely to be demolished. However, our government has asked us to ensure that every school in Christchurch has a recent structural engineer's report. There is concern that the cumulative damage of 9,500 aftershocks will have significantly damaged those buildings even though initially they were seen to be structurally sound. In addition to the findings of the structural assessment, a series of subsidence and liquefaction have seriously compromised the foundation of many of those buildings. Damage to foundations has in turn put pressures and stresses on other structural fixtures of buildings limiting their durability. This has meant for the Ministry of Education that before we can repair any of these schools, we must also undertake geotechnical reports of the ground, the land, on which the schools sit.

(Slide 54) These are our key observations. The schools worst affected were those of brick construction. Those schools on floating platforms were able to move during the earthquake. They were affected by subsidence where the ground underneath the floating platforms disappeared. Wooden buildings, wooden schools feared the best, with virtually no structural collapses. No students were harmed or killed in any of our school buildings in the Canterbury earthquakes, and no building fully collapsed. And this was because of the seismic strengthening work that we had done to keep the buildings structurally sound.

(Slide 55) However, while these schools retained their shape, and this was good from a life safety perspective, they are not fit for purpose for ongoing use. As you can see from the pictures we have shown you, the schools are intact, but we have still had to demolish them because they are not structurally sound and fit for purpose for future use.



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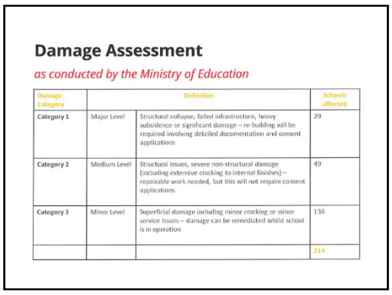
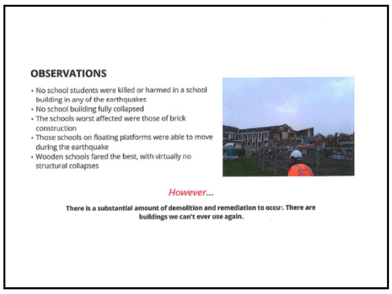


Damage Category	Definition		Schools affected
Category 1	Major Level	Structural collapse, failed infrastructure, heavy subsidence or significant damage – re-building will be required involving detailed documentation and consent applications	29
Category 2	Medium Level	Structural issues, severe non-structural damage (including extensive cracking to internal finishes) – repairable work needed, but this will not require consent applications	49
Category 3	Minor Level	Superficial damage including minor cracking or minor service issues – damage can be remediated whilst school is in operation	136
			214

Slide 53



Slide 54

(Slide 56) Rebuilding Canterbury – the process of rebuilding Canterbury will be long and drawn out. The central business district was closed for 11 months, and has only just starting to reopen. The area has seen significant population shift.

(Slide 57) This graph represents student movement in the year since the February earthquake. The blue line represents the number of students that vacated the area after the earthquake. This number peaked at 7,581 students, whose families took them out of the area. The green line shows the students returning. Note no students returned for two weeks after the earthquake.

(Slide 58) There have been a large number of aftershocks that continue to plague the region. This is a unique feature of the Canterbury earthquake. The region is hit with several aftershocks a day, some large ones like the magnitude 5.8 and magnitude 6 aftershocks on the 24th of December only four weeks ago. These aftershocks have impeded school remediation efforts.

(Slide 59) Up to 75% of work done to remediate schools after September 2010 was lost during the 2011 earthquakes. So we had to start again.

(Slide 60) This graph shows the aftershocks are progressively moving away from the central business district and out to sea. The pink circles are the latest aftershocks and are moving offshore.

(Slide 61) After the earthquake, the government quickly classified all land in Christchurch into zones – red, orange, green, or white. Land in the red zone meant that the land cannot be built on or lived on as it is a risk of further liquefaction or earthquake damage. Land repair will be prolonged and uneconomic. Land in the orange zone requires further assessments before it can be built on or lived on. Buildings in the green zone are fine to be repaired or rebuilt. Mapping is still underway for buildings in the white zone.

(Slide 62) The identification of red zones has moved communities. This has had a direct impact on the number of students attending schools in the area, and in some cases significantly reduced the viability of having a school in that location.

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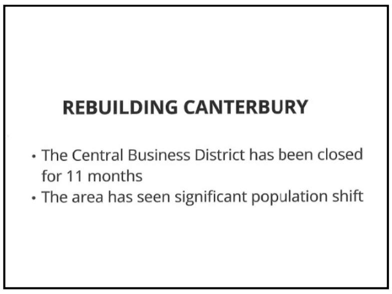

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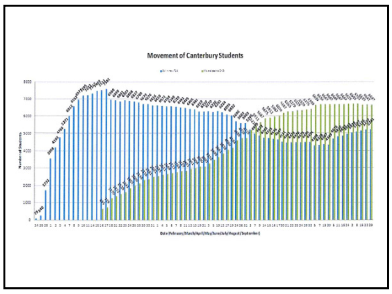

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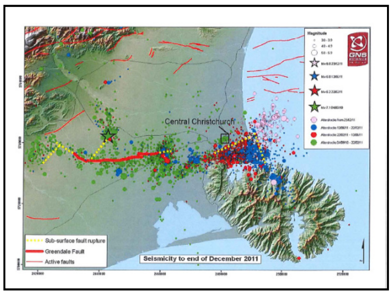


Slide 60

We are now going through all of our state schools conducting geotechnical assessments of the land.
(Slide 63) Initial figures indicate the cost will be about 15 billion New Zealand dollars, but it could be higher. New Zealand's annual GDP is around 200 billion New Zealand dollars a year, and the government has committed 1.4 billion New Zealand dollars to the Christchurch area in the education area.

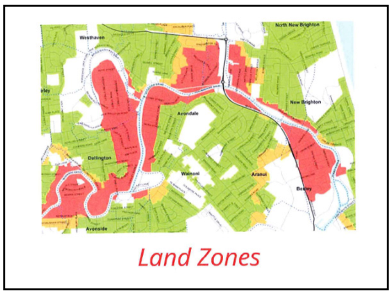
(Slide 64) The key lessons from the earthquake are as follows. The earthquakes proved the benefit of seismic strengthening for building strength. We saw the benefits of investing in schools to strengthen the buildings we had. There is now an increased awareness of ground failure as an earthquake consequence, and the need to conduct geotechnical assessments of the land on which our schools are located. Progressive improvement of design standards has helped buildings perform well, but we need to continue to upgrade these standards to future proof our buildings. In the Ministry, we also need to undertake a review of our school property portfolio to identify priority areas for seismic strengthening, not just in Christchurch but all over New Zealand. All of the information that I have referred to is available as references and Web links that I will provide to you. We invite you to continue talking with us as we work through our problems and our challenges around the Christchurch earthquake. Thank you for listening to us today.

(Applause)

Moderator:

Thank you very much, Ms. Kim Shannon, Mr. Wayne Tacon.

Let us take a ten-minute break.



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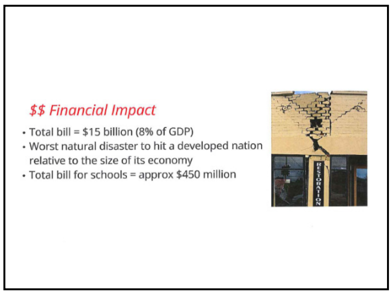

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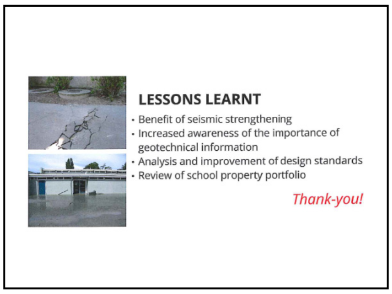

Slide 64

Commemorative Lectures

Kim Shannon

Lecture

The Great East Japan Earthquake: Schools as the Emergency Evacuation Site and its Role for the Community

Jun Ueno

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Division of Architecture and Urban Studies,
Faculty of Urban Environmental Science,
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1977.03 D.Arch.,Tokyo Metropolitan University Doctor of Engineering
1977.12 Assistant, Faculty of Engineering, Tokyo Metropolitan University
1984.10 Assistant Professor, Faculty of Engineering, Tokyo Metropolitan University
1993.04 Professor, Faculty of Engineering, Tokyo Metropolitan University
2005.04 Professor, Faculty of Urban Environmental Sciences, Tokyo Metropolitan University
(Integration and reorganization of Metropolitan Universities)
Director of Basic Education Center, Tokyo Metropolitan University
2009.04 Vice President, Professor, Faculty of Urban Environmental Sciences,
Tokyo Metropolitan University
Director of Academic Education Center, Tokyo Metropolitan University

Awards
1995 The prize of AIJ 1995 Research Theses Division

2007 Annual Architectural Design Commendation of AIJ（GUNMA KOKUSAI ACADEMY）
2009 The Prize of Fukushima Architectural and cultural Design
(Kawahigashi Gakuen Elementary School, Aizuwakamatsu city)

Moderator:

Now, let us go on to the second part of today's seminar. Mr. Jun Ueno, vice-president of the Tokyo Metropolitan University will deliver a lecture, entitled "The Great East Japan Earthquake: Schools as the Emergency Evacuation Site and its Role for the Community."

Please refer to the materials at hand for the profile. Let me introduce Professor Ueno.

Mr. Jun Ueno:

(Slide 1) Nice to meet you. I am Jun Ueno. I have visited several schools that were used as emergency evacuation sites after the earthquake. Today, I will introduce some of the representative cases.

Due to the earthquake, nearly 20,000 people died. I extend a heartfelt condolence to those victims and the tremendous number of afflicted people.

First comes Minami Sanriku. This shows how lively the town was before the earthquake, and the next one is after the earthquake. You can see that the town was completely destroyed. The school, Shizugawa Junior High School, that we visited for investigation is located here.

Again, you can see that the whole town suffered catastrophic damage. The junior high school happens to be on a hill and served as an emergency evacuation site for local residents.

This is called a Reconstruction Assistance Map, which shows areas stricken by the tsunami in detail based on the investigation. The school we investigated happens to be located on a hill and could escape undamaged.

(Slide 3) This shows the whole town. This is Shizugawa High School, which was also used as an emergency evacuation site.

(Slide 4) This is the disaster prevention center, where a female staff member risked her life to continue broadcasting evacuation alerts to local residents and finally lost her life.

The tsunami that hit Minami Sanriku had a height of over 15 meters. A hazard map had been prepared with the presumed maximum tsunami height of five meters. Therefore, the tsunami was far beyond imagination.

(Slides 5-8) I visit devastated areas once a month. People lay flowers here.

(Slides 9-10) This is a photo taken at the time of the investigation in May. This place, the entrance of Sanriku town, is located around 4 kilometers from the coast, but as you see, a ship was carried upland for such a distance. The tsunami came up along the river.

(Slides 11-17) Damage can be observed all over the area.

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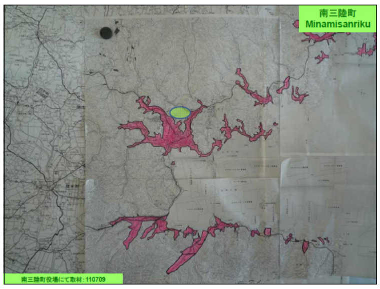

Slide 3

(Slide 18) Of course, the heap of rubble has been removed gradually as time goes on. However, this does not necessarily mean that the recovery has progressed. Rather, the reconstruction has just stared.
(Slide 19) This is a fish market severely damaged.
(Slide 20) This shows how roofing materials were dragged along with the backrush of the tsunami.
(Slides 21-25) Cleanup has been started here, and signs of reconstruction can be observed gradually.
(Slide 26) This is the town's hospital.
(Slides 27-34) The hospital was completely destroyed up to the third floor. You can see what tremendous energy the tsunami had, can't you?
(Slides 35-36) This ship was swept away over the three-storied hospital and was dragged back with the backrush to become hung up here.
(Slides 37-39)
(Slide 40) Slides showing Shizugawa Junior High School. A field of rubble continues as far as one can see. The photo shows that the whole town at the foot of the hill was devastated.
(Slide 41) This photo was taken at the front of Shizugawa Junior High School, where we have been continuing investigation.
(Slides 42-45) The rubble has been removed little by little, but the situation is as I explained before.
(Slides 46-49)
(Slide 50) This is a facility for the elderly people with a nursery home, which is located at a slightly high place. The facility is a one-storied building. (Slides 51-52) The inside of the facility was destroyed as you see. As this was a facility for handicapped elderly people, each staff member could only help one elderly person at a time to evacuate to a safe place, and a considerable number of people became tsunami victims here. (Slide 53)
(Slides 54-56) This is the makeshift government office.
(Slides 57-58) There is a town's arena or gymnasium somewhat far from Shizugawa Junior High School. This facility, which is located at a somewhat elevated place and escaped the tsunami, also functioned as an emergency evacuation site.
(Slides 59-61) It is said that immediately after the tsunami, as many as 1,000 evacuees headed for this facility.

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Commemorative Lectures

Jun Ueno

(Slide 62) This is the junior high school. The earthquake occurred a little after 2:40 in the afternoon, and the students, teachers, and school staff were all still at school. It appears that within an hour, they witnessed an awful scene where the tsunami swept over the whole town. The school principal gathered all students in the gymnasium to avoid their seeing such an awful scene. The principal gave due consideration in order to prevent them from getting seriously traumatized. However, I heard that one female student, who went back to her classroom to pick up her jacket, happened to witness the scene and suffered hyperventilation due to strong psychological trauma.

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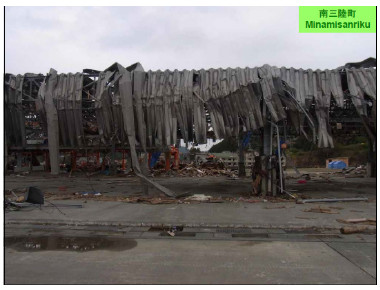

Slide 20

(Slide 63) From a rather early stage, temporary residences started to be built on the school ground.
(Slides 64-65) Fortunately, as this school has a vast site, physical education activities were not hindered by these temporary residences.
(Slide 66) At the time of the occurrence of the earthquake, all of the 308 students and all teachers and school staff were inside the school. Fortunately all students survived. This suggests the significance of the structural secureness of school buildings.

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From immediately after the earthquake, 250 local residents came to take refuge, and a total of 600 people started refuge life at the school on that night.

Under such circumstances where the local communities were completely destroyed, the school was isolated with no help as if it were a lonely island. Water, food, heaters, warm clothes, and other necessities were all in short supply. A water tank was filled with water, but considering the possibility that such isolated refuge life would continue for days, the school principal decided to provide one glass of water equally to all evacuees.

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As you know, it was a very cold night. There was of course no power supply and it was completely dark. As there were also no means for heating, the students and evacuees made groups and took off all curtains from the classrooms to wrap themselves up for warding off the cold.

(Slide 67) This is very important. Communication means were all lost. No information came from the outside, nor were they able to seek information themselves. Not one bit of information came in. I felt that such complete loss of information poses an extremely serious problem. I heard that it was not until ten days later that satellite telephones finally became available.

(Slides 68-69) However, as electricity, gas, and water supply and other infrastructure were not recovered, the recovery of school functions was also delayed. Nevertheless, before school started officially, daily life seems to have been well organized under the guidance of the teachers, including getting up at a fixed time every morning, cleaning the surroundings, having meals, holding group leader meetings, attending the all-school assembly, and studying individually even though there were no school classes.

(Slide 70) I have to reiterate the seriousness of problems with toilets. There was no water supply and toilets were clogged. I will explain it later, but the same trouble arose at the time of the Great Hanshin-Awaji Earthquake.

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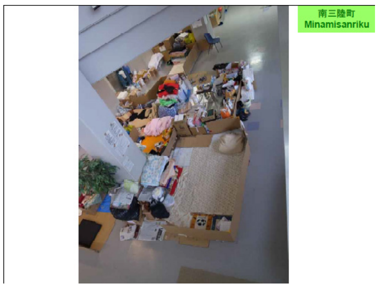

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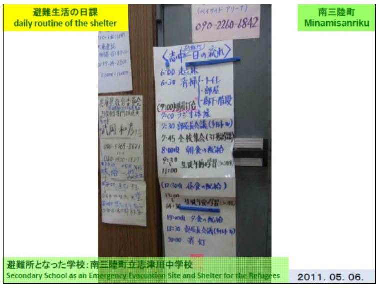
The evacuees dug ditches in the school ground, covered them with blue tarpaulin, and thus made temporary, literally temporary, toilets by themselves. However, these temporary toilets became full very soon. Then, they covered them with soil and dug ditches at another place to make new toilets. Such efforts were not unique to this school but were common in all schools which accepted evacuees. It may seem that I am repeating myself but the same was observed everywhere at the time of the Great Hanshin-Awaji Earthquake, which occurred 17 years ago.
(Slides 71-72) Schools became the living space for evacuees but as you know, school toilets are almost all Japanese-style. These toilets are very inconvenient for elderly people and those with handicaps.
(Slides 73-75) These are rescue materials.
(Slides 76-77) The photos show how schools were used as emergency evacuation sites.
(Slide 78) At this school, the evacuees occupied randomly in classrooms at first. Later, the school principal carefully divided them into teams and groups based on each community, and then asked them to move from classrooms to the gymnasium.

As emergency evacuation sites in Minami Sanriku around Shizugawa River were integrated, the number of the evacuees at the school, which was 300 immediately after the earthquake, decreased slightly and then increased due to evacuees moving in from other sites. Increases and decreases were thus repeated



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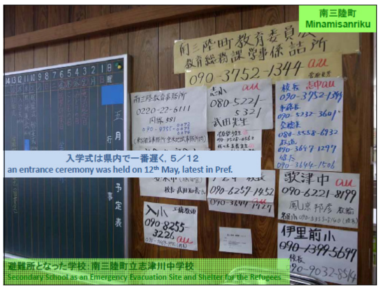

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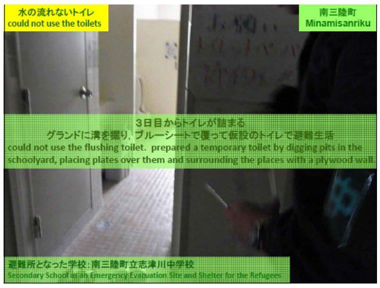

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(Slide 79) This may be trivial, but groups of people who had originally taken refuge at the gymnasium and groups of people who had been in classrooms but later moved to the gymnasium seem to be separated in this manner.

(Slides 80-81)

(Slide 82) Naturally, the number of the evacuees decreased gradually.

(Slides 83-84) On August 19, all evacuees left and the school was reopened on August 22. The school got back its gymnasium.

For the honor of the evacuees, I will add that they returned the gymnasium to the school after cleaning it up completely and without any flaws.

(Slide 85) Regarding this school, due to delayed reconstruction of infrastructure on many levels, the school functions were not recovered until around two months after March 11.

(Slide 86) In May and June, children could finally start to come to school. They seem to be cheerful and excited, but many of them lost either or both of their parents and around half of them lost their houses. Therefore, they must have been extremely psychologically unstable.

(Slide 87) The teachers had tried hard to somehow reopen school as soon as possible, while paying attention to the evacuees and at the same time giving due consideration to the students' mental trauma. I heard from them that they suffered from considerable fatigue in June or July. (Slide 88)

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(Slides 89-91) These are temporary residences constructed on the school ground. It must be very cold there today. (Slide 92) Nothing has changed since the Great Hanshin-Awaji Earthquake; in the event of such disaster, elderly people who were forced to move into temporary residences, separated from their own communities, are apt to be isolated.

(Slide 93) Until August, the school coexisted with the evacuees staying at its gymnasium or living in temporary residences constructed in its ground.

I will skip these slides. (Slides 94-101)

(Slide 102) Let me talk a little about the Great Hanshin-Awaji Earthquake. It was 17 years ago. Immediately after the earthquake, 310,000 people took refuge and nearly 80% of them sought refuge at schools.

(Slide 103) As I said before, the same troubles experienced in the latest Great East Japan Earthquake had occurred at that time.

(Slide 104) I investigated closely how schools functioned as emergency evacuation sites and compiled it into a book. The book did not sell at all at that time but I heard that it sold out in three weeks after the Great East Japan Earthquake. The book is now out of print, but a PDF file covering its entire content is available on the website of the Osaka University Press. Please take a look at it.

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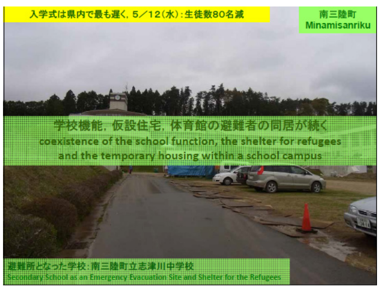

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(Slide 106) The Great Hanshin-Awaji Earthquake was a disaster that intensively struck an inner-city area and had a range of several kilometers in width and some 10 to 20 kilometers in length. However, the Great East Japan Earthquake damaged an area of over several hundred kilometers and it took much more time for recovery or reaching out to disaster victims, due to the cutoff of the distribution network and other factors. (Slide 107) Again, let me reiterate it: Directly after the earthquake, 310,000 people took refuge and nearly 80% of them sought refuge at schools. (Slide 108 -109)

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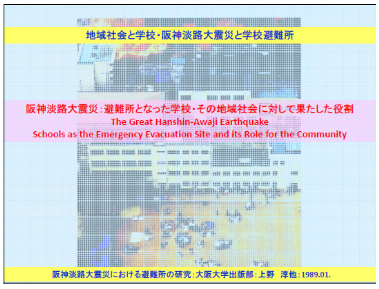

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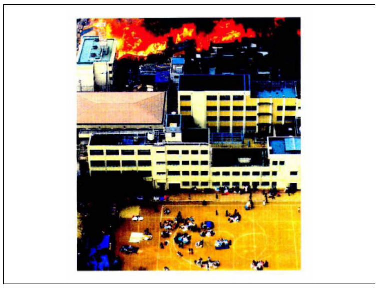
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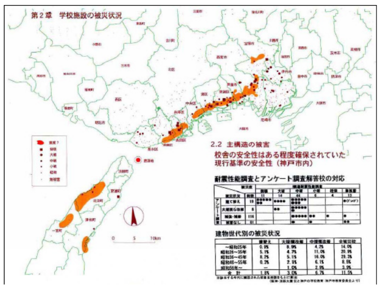
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(Slide 110) This shows how evacuees spent refuge life at a gymnasium at the time of the Great Hanshin-Awaji Earthquake. The earthquake occurred on January 17, and it was at the end of August, more than six months later, that all evacuees left and schools could return to normal. Compared with this, the closure of school evacuation sites was rather smooth in the case of the Great East Japan Earthquake.

(Slide 111) The situation concerning toilets was the same at the time of the Great Hanshin-Awaji Earthquake. They dug ditches in school grounds and made enclosures with veneer boards and blocks. When a ditch became full, they covered it with soil and dug another ditch next to it.

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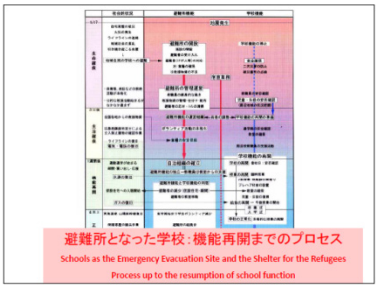

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(Slide 112) I would like to once again emphasize here that the same activities were repeated.
(Slide 113) At that time, I wrote several papers, in which I pointed out that evacuees struggled to survive for around three days before city functions started to be recovered after the Great Hanshin-Awaji Earthquake. However, in the case of the Great East Japan Earthquake, distribution was hampered over wide areas, and it seems to have taken two or three weeks for restoring city functions and people had to bear the inconvenience longer.

Next, I will talk about Rikuzen Takata. The city was also severely damaged. Takata Dai-ichi Junior High School, which we continuously visit for investigation, is here on a hill. The school was not damaged and functioned as an emergency evacuation site. Now, the idea to move the whole city up to elevated places is under discussion. This may be a realistic suggestion in a sense.
(Slide 114) This is a city gymnasium, which was designated as an emergency evacuation site, but was hit by the tsunami of over 15 meters in height. The gymnasium was flooded almost up to the ceiling and many of the evacuees drowned here.
(Slide 115) This is the entrance to the city.
(Slide 116) As you see, the tsunami came up along the river, as far as three kilometers, four kilometers...
(Slides 117-121) The whole town was completely destroyed.

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(Slides 122-124) This was a big bridge, but was swept away up to the upper stream.(Slide 125)
(Slide 126) This is the municipal office.
(Slide 127) According to media report, one-quarter of the city officials were killed. Therefore, it can be assumed that they may be suffering serious shortage in human resources even today, in preparing a reconstruction plan. Assistance from other local governments will be urgently needed in these areas.

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(Slide 128) This is the makeshift city government office. (Slides 129-131)
(Slide 132) Here again, the prefectural hospital was utterly destroyed up to the fourth floor.
(Slides 133-136) These show the inside of the hospital building.
(Slides 137-140) I heard that patients barely escaped to the rooftop with doctors and nurses.
(Slide 141) This is a photo taken from the rooftop of the prefectural hospital.
(Slides 142-148) The whole city was flooded. The rubble was removed gradually from June, July to August.
(Slide 149) As you see, a five-storied apartment building was destroyed up to the fourth floor.

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The height of the tsunami was recorded to be over 15 meters. (Slides 150-154)
(Slide 155) This is the school where people took refuge. Again, the school is located on a hill.
(Slide 156) Therefore, the school was not damaged and it is recorded that 1,000 residents from the foot of the hill came up to school directly after the earthquake. The school accepted many evacuees. For over four months, the school concurrently functioned as an educational facility and as an emergency evacuation site.
(Slides 157-158) These clearly show how the school balanced its functions as an educational facility and as an emergency evacuation site.

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(Slide 159) This is a classroom for domestic science, but was used as the headquarters of the self-governed evacuation site, or the headquarters of the self-governing organization of the evacuees. I investigated in detail and found that the evacuees had a high sense of ethics and their self-governing organization worked very effectively. I would like to emphasize here in front of many guests from overseas that these examples indicate a high sense of ethics or morals of the Japanese people.
(Slide 160) 1,000 evacuees gathered at the gymnasium right after the earthquake and there still were 500 as of May.
(Slide 161) As temporary residences were completed, the evacuees moved out.
(Slides 162-164) The number of the evacuees decreased gradually to 500 in May, (Slides 165-166) to 350 in June, (Slide 167) and to 190 in July.

The situation is almost the same at any schools sheltering evacuees. School facilities are not very comfortable to live in. They lack insulation efficiency and cannot keep out the cold. Furthermore, evacuees cannot have privacy. The floor of a gymnasium is usually constructed to be rather soft and shakes in response to slight vibrations. If any person wakes up late at night to go to the toilet, that causes the floor to shake and wakes others.

This is an article of the Mainichi Shimbun dated August 11.
(Slide 168) On August 12, all evacuees left the gymnasium and things returned to normal. The second semester started on August 19. Here again, the evacuees cleaned up the gymnasium before they left and returned it to the school without any flaws.
(Slides 169-170) This is the manual for refuge life prepared by the self-governing organization. You can see that the evacuation site was well organized and governed in an orderly manner by the organization.
(Slide 171) Various types of teams were organized, and they rotated daily duties such as cleaning the surroundings, carrying in rescue materials, and cooking in teams. The self-governing organization and the school principal always consulted with each other and we can confirm that they realized very smooth coexistence of the functions as an educational facility and as an emergency evacuation site.
(Slide 172) Evacuees were divided into teams based on their home communities to form groups and the site was run by the units of such groups.

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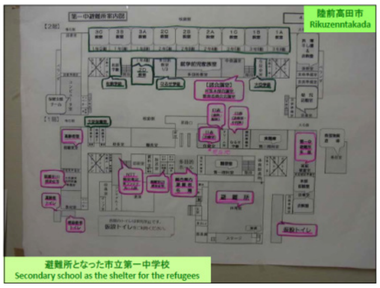
(Slide 173) The school ground was used as a parking lot.
(Slide 174) This is the kitchen. Teams of the self-governing organization took turns to prepare meals three times a day for the evacuees, around 500 in number at that time.
(Slide 175) The school infirmary was used as the headquarters of the Red Cross medical team. As you know, it was still very cold at that time, and there were risks of influenza and O-157 outbreak. The school nurse and the staff of the medical team jointly made the utmost effort to prevent infectious diseases.
(Slide 176) The first semester began on April 22, a little later than usual. The school continued to function as an educational facility and as an emergency evacuation site concurrently until August.
(Slide 177) Also at this school, students were at school when the earthquake occurred. They were having a rehearsal for the coming graduation ceremony in the gymnasium. Fortunately, all students survived. Then, they were divided by class and by gender into each classroom and started refuge life on that night. The school principal offered the gymnasium to a crowd of evacuees, which were as many as 1,000 in number right after the earthquake. This school has around 300 students and nearly half of them lost their houses in the city.



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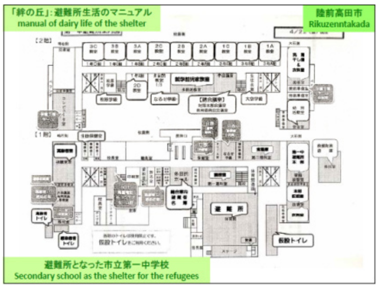

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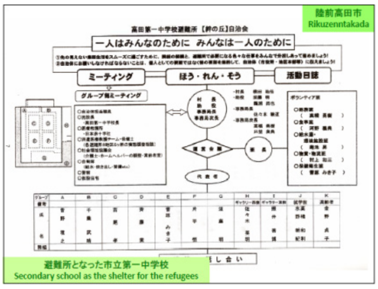

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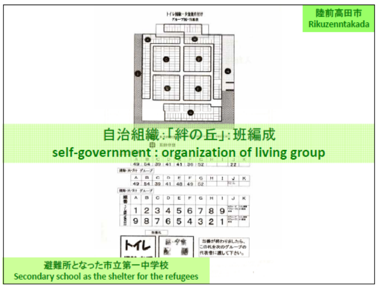

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(Slide 178) Evacuees included elderly people and handicapped people, so-called “people vulnerable to disasters.”
(Slide 179) Those people were taken care of at the health room. There were also young families with babies and small children.
(Slide 180) Again, a complete loss of information occurred here, too. Telephones were dead. No TV, no radios, no Internet. There were no means to obtain information, and there was complete darkness.
(Slides 181-184) These are temporary residences. As the school ground was used as a parking lot, the school had no space for physical class activities until August.

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They managed to finish physical class curricula, using gymnasiums of undamaged neighboring elementary schools or junior high schools. The students had to take a bus to go to this school and that school once a week.

(Slides 185-195) July, August… The school gradually recovered its original functions, and as I said before, it finished functioning as an evacuation site and things returned to normal in August.

(Slides 196-198) The photo shows how people live in rather deserted temporary residences. These people have lost their jobs and have no income source. What is worse, they are separated from their own local communities, which is a cause of fear for their future.

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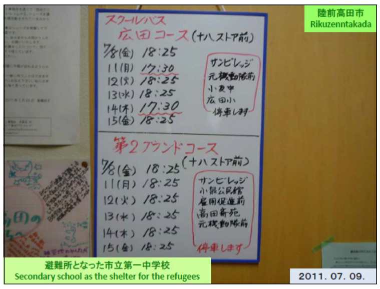

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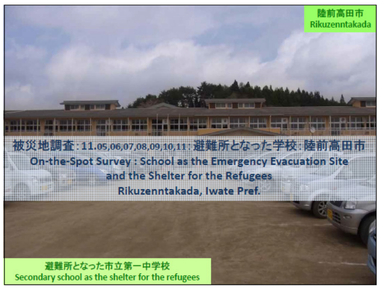

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(Slide 199) As I have repeatedly mentioned, schools have functioned as an emergency evacuation site or a shelter for long periods as in the case of the Great Hanshin-Awaji Earthquake.

That night, it was cold and snowy and was completely dark with no power supply. The only two oil heaters that the school had were for elderly people. Others took off all the curtains in classrooms to wrap themselves up for warding off the cold. Making temporary toilets by digging ditches in school grounds was also the same as in the case of the Great Hanshin-Awaji Earthquake.

As emergency food, one bun for each person was finally delivered on the second day and rice balls were provided from undamaged neighboring municipalities. Thanks to such assistance, disaster victims managed to survive, but the life securing stage seems to have taken three times longer than in the case of the Great Hanshin-Awaji Earthquake.(Slide 200)

(Slide 201) The Ministry of Education, Culture, Sports, Science and Technology compiled the urgent recommendations in June. I also joined the compilation work as a member and made suggestions on functions that schools should fulfill at each stage.

(Slide 202) As you can see, schools are very important as community shelters. Schools are always expected to function as such, whether they wish to or not. Therefore, it is important to consider what functions schools should fulfill at each stage in an emergency.

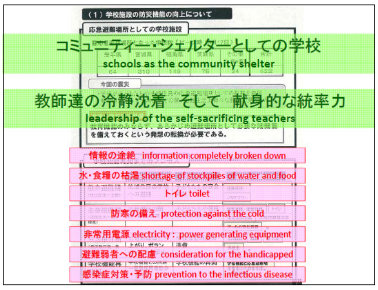
Furthermore, the problem common in these disasters is the loss of information after the whole town or city is destroyed. Even if there is much water stored in a tank, they are not sure how long they need to survive by themselves with the water and food they have at hand. Problems with toilets are extremely serious. The cold and darkness without power supply also constitute major problems.

At the time of the Great Hanshin-Awaji Earthquake, which intensively struck an inner-city area, emergency power supply vehicles came to schools functioning as shelters promptly from areas not affected, such as Hiroshima and Nara, and they had power as early as the next day. However, this time, the earthquake damaged huge areas, which made it much more difficult to restore logistics.

Special attention needs to be paid to those who have difficulties in taking refuge, such as elderly people and young families with babies and small children. I know many cases at the time of the Great Hanshin-Awaji Earthquake where handicapped people could not stay comfortably at shelters and had no choice but to return to their half-broken residences. This is extremely dangerous.

One of the problems to be emphasized this time was how to prevent infectious diseases.

Furthermore, I would like to stress the significance of the role of teachers at schools.



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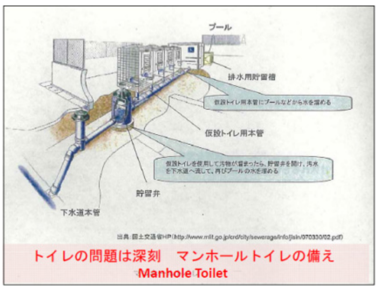

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For example, the vice principal of Shizugawa Junior High School, with whom I have been on familiar terms through the investigation, stayed at school for 48 days without going back home and took care of the students and evacuees. He had no means of knowing what happened to his own house or his family right after the earthquake, but he chose to stay at school for the students and evacuees.

The situation was the same in many other schools, as in the case of the Great Hanshin-Awaji Earthquake. I would also like to stress that it was Japanese teachers' high professional sense and calm and dedicated efforts that enabled schools to maintain functions as emergency evacuation sites.

Nevertheless, I am not sure whether such duties should be assumed by teachers. This needs to be discussed fundamentally. I myself cannot reach a conclusion.

(Slides 203-204) Well, let me change the subject.

In addition to schools that sheltered many evacuees, there were many other schools that were severely hit by the tsunami.

(Slide 205) The first floor of this school was destroyed by the tsunami. The children and local residents evacuated to the rooftop and were rescued by a helicopter of the Self Defense Force next morning. It must have been very cold.

The school is located 1.2 kilometers from the Sendai Bay, and the stained parts were flooded. At present, the school uses part of another school that was not damaged by the tsunami.

(Slide 206) I heard that 129 schools were damaged somehow by the tsunami, but still only 19 of them have full-fledged reconstruction plans.

(Slide 207) Needless to say, the neighboring area was utterly destroyed. If they intend to move the whole neighborhood to higher elevations, they need to picture how to reconstruct the whole town and how to reconstruct the school, otherwise they cannot make any concrete plans.

I always say that a school represents a town and a town represents a school. It is not enough to only move the school to a higher place for safety but need to consider how to revive the town as a whole and how to revive the school accordingly.

(Slide 208) At the committee meeting, in which Professor Kabeyasawa, the next lecturer, and I participate as members, we talked about the proposal to construct schools at higher places or otherwise prepare evacuation routes to higher places.

(Slide 209) One example is a school that has a tall school building. There actually were cases where students and teachers survived by evacuating to the third floor, the fourth floor, or the rooftop.

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(Slide 210) For example, instead of trying to make a plan solely for a school, it would be a nice idea to integrate a school with other various community facilities and construct them at safe places in harmony with the whole community, so that they can serve as the headquarters in an emergency.

(Slide 211) Or, it would also be nice if a school normally serves as various platforms for the local community jointly with parks, daycare centers, and other community facilities and, in an emergency, becomes a base for resident support.

I presented these pictures as urgent recommendations. These are of course some examples of the measures. When I visit the devastated areas in Sanriku in the Tohoku region, I strongly feel the significance of the perspective to consider how to reconstruct industries and businesses in these areas, how to revitalize communities, and how to rebuild schools in line with these moves. However, I have to admit that there still is a long way to go.

(Slide 212) I think that the Japanese people are now being tested concerning how the whole nation can support or back up efforts of these devastated areas for the recovery in a true sense.

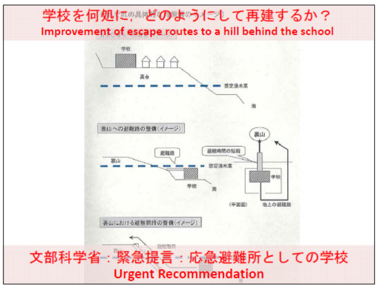
(Slide 213) Thank you very much for listening.

(Applause)

Moderator:

Thank you very much, Professor Ueno

Well, let us take a ten-minute break.



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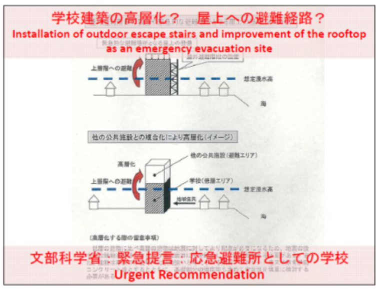

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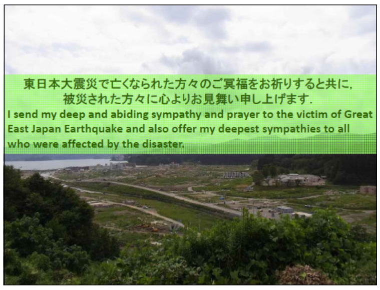

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Lecture

Damages to School Buildings Caused by the Great East Japan Earthquake

- Investigation and Post- earthquake Evaluation by Architectural Institute of Japan and Ministry of Education, Culture, Sports, Science and Technology -

Toshimi Kabeyasawa

Professor, Doctor of Engineering,
Earthquake Research Institute,
The University of Tokyo, Japan

Toshimi Kabeyasawa

1976 B.Arch., Faculty of Engineering, The University of Tokyo
1978 M.Arch., Faculty of Engineering, The University of Tokyo
1980 Assistant, Faculty of Engineering, The University of Tokyo
1981 Assistant, Faculty of Engineering, Yokohama National University
1987 Assistant Professor, Faculty of Engineering, Yokohama National University
1996 Professor, Earthquake Research Institute, The University of Tokyo
Doctor of Engineering, Architect on Structure Design, Architect

Awards and Academics
1989 The Encouragement Prize of Architectural Institute of Japan 1989
2008 The Prize on Construction of 18th NIKKEI BP
2008 Project general manager, Committee on Reinforced Concrete Construction, Architectural Institute of Japan
2011 Project general manager, Subcommittee on Seismic Capacity of Educational Buildings, Architectural Institute of Japan
Chairman, Committee on Technology Evaluation and Vice-chairman, Committee on Seismic Evaluation, The Japan Building Disaster Prevention Association
Chairman, Committee on Seismic Evaluation, The Building Center of Japan

Moderator:

Now, we will go on to the third part.

The last lecture is by Mr. Toshimi Kabeyasawa, professor of the Earthquake Research Institute of the University of Tokyo, entitled “Damages to School Buildings Caused by the Great East Japan Earthquake –Investigation and Post-earthquake Evaluation by Architectural Institute of Japan and Ministry of Education, Culture, Sports, Science and Technology–.”

Please refer to the materials at hand for the profile. Let me introduce you Professor Kabeyasawa.

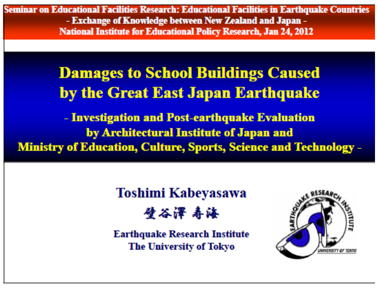
Mr. Toshimi Kabeyasawa:

(Slide 1) Hello, I am Kabeyasawa from the Earthquake Research Institute.

I would like to talk under the title as introduced. I will report on the damage to educational facilities, in particular damage by the shock of the earthquake. Damage due to the ground motions, or structural damage, did not attract people’s attention this time, but the Architectural Institute of Japan conducted investigation on commission from the Ministry of Education, Culture, Sports, Science and Technology (MEXT). This is the report of the results of the investigation.

(Slide 2) The latest earthquake was accompanied with the tsunami and, in particular, the nuclear accident in Fukushima prefecture. Therefore, how to construct educational facilities cannot be discussed without considering the ongoing radiation problems. Although damage due to the ground motions has not attracted much attention, a considerably wide area actually suffered the damage.

(Slide 3) The Architectural Institute of Japan independently conducts investigation of damage on various buildings, but regarding educational facilities, it investigated around 700 buildings in detail in commission from MEXT. The investigation was not merely to investigate damage but to categorize damage in relation to reconstruction. As explained in the case of New Zealand where the three categories1, 2, and 3 were used, the investigation by the Architectural Institute of Japan used five categories, while taking into consideration how to reconstruct damaged facilities in the future. You may know this very well.



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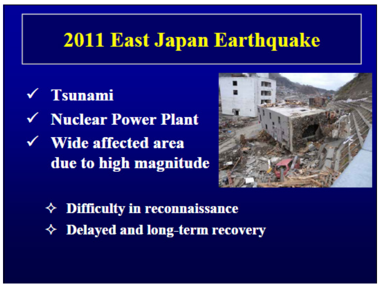

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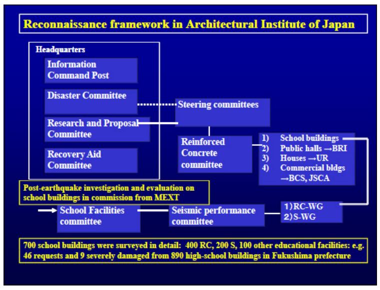

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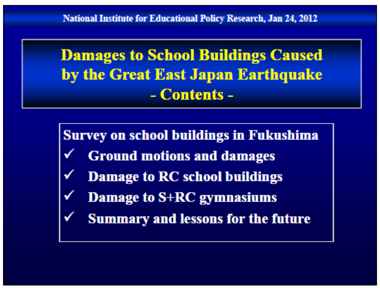

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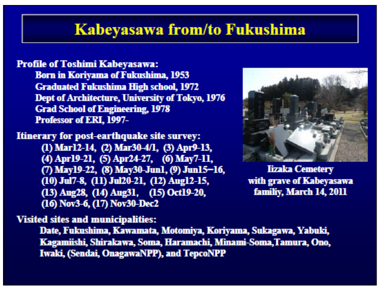


Slide 5

Slide 6

Major targets were reinforced concrete school buildings and steel gymnasiums, public halls, and other education-related facilities. The total number was 778. I will later explain statistical data.

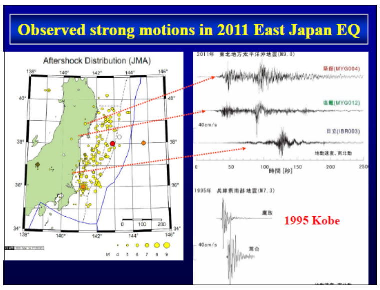
(Slide 4) Today, I will talk about the ground motions, damage to reinforced concrete school buildings, damage to gymnasiums which are framed with steel with the bottom parts made of reinforced concrete, what we have learned from these facts, and what we should do for structural planning in the future.

(Slide 5) I have seen various cases of earthquake disasters, but I personally had special feelings about the latest one. The title of this slide says “Kabeyasawa from/to Fukushima.” I am from Fukushima and my parents’ house is located there, so I could enter Fukushima the very next day. Since then, I visited the prefecture for investigation 17 times, or for more than a one-month period in total.

(Slide 6) Fukushima prefecture consists of three regions, Aizu region, Nakadori, and Hamadori, roughly divided by the southern part of the Abukuma Mountains and the Ou Mountain Range. The Aizu region was also included in the investigation targets, but the damage was not so serious, and I did not visit there. Instead, I think I was able to visit almost all major cities in Nakadori and Hamadori.

(Slide 7) First, I will briefly explain ground motions. Available ground motion data are the results compiled later. The K-net did not function for about three days right after the earthquake due to the blackout, and during this period, we did not understand how large the earthquake was while we were conducting the investigation.

However, even in Tokyo I knew that the earthquake was an extremely huge one of magnitude 9 and the tremors lasted for around two minutes. The duration was significantly long, compared with, for example, the 1995 Hyogo-ken Nanbu Earthquake. Nevertheless, the impact on buildings was not as strong as that of a near field earthquake.



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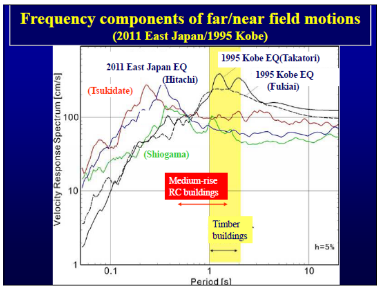

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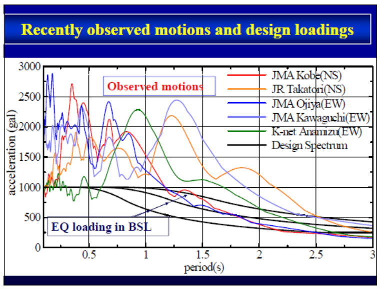

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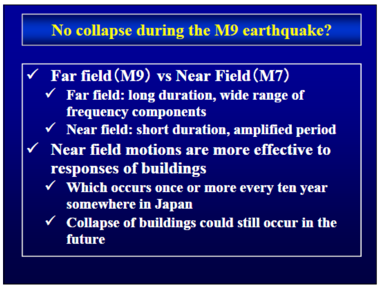

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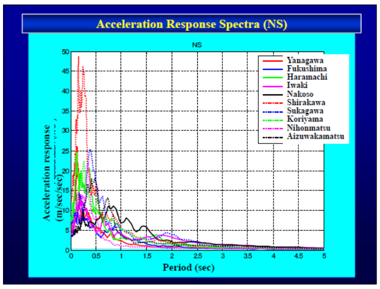

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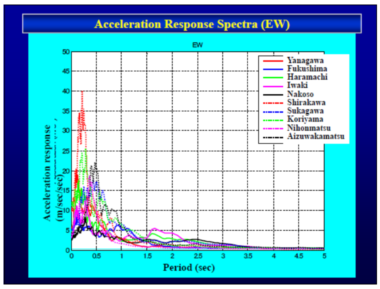


Slide 12

There are many ways for explaining why a near field earthquake has a strong impact on buildings. (Slide 8) However, to put it simply, a little bit longer frequency of around one to two seconds, instead of a short frequency, may sometimes be generated due to overlapping of waves. We have learned from the earthquake in Kobe that an earthquake with a rather slow frequency, a frequency of around one second or a little bit longer than one second, causes tremendous damage to structures. This time, the level of such damage causing frequency components was half or less of that observed in Kobe.

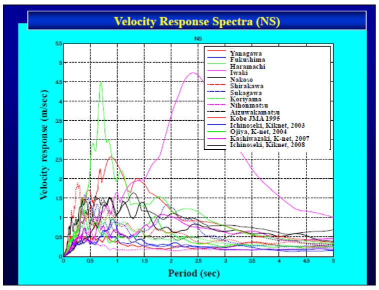
(Slide 9) In other words, the Great East Japan Earthquake was of the level close to the design loadings, while the Hyogo-ken Nanbu Earthquake was far larger than the design level, from 2 times larger to 2.5 times larger. In a sense, the Great East Japan Earthquake showed how much damage would be caused by an earthquake approximately the same level as the design loadings.

(Slide 10) As you can see, far field and near field earthquakes have different features, but a critical impact on buildings is caused by near field earthquakes. Last year's earthquake in New Zealand was also a near field earthquake. It does not mean that as we have experienced a magnitude 9 earthquake we do not need to consider a risk of collapse of conventional buildings. Rather, we have to bear in mind the fact that near field earthquakes occur once every ten years, or once or more every ten years somewhere in Japan.

(Slides 11-12) These show acceleration response spectra of ground motions. Although some significant responses of 3G or 4G are observed at some points, they are extremely short frequency components and it may be surprising but they do not directly cause collapse or damage of buildings. Frequency components of ground motions are very significant in terms of damage on buildings.

(Slide 13) Still, some epicenters were near the coast or off Iwaki and certain spots near the epicenters show large spectra around one second.

(Slide 14) Around these areas, structural damage was considerable. I will show you later.



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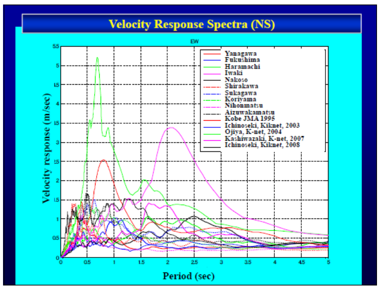

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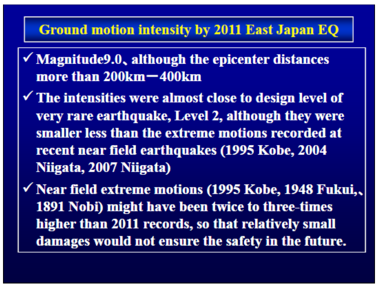

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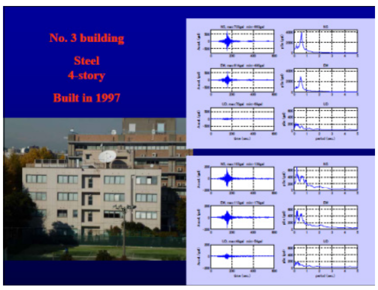

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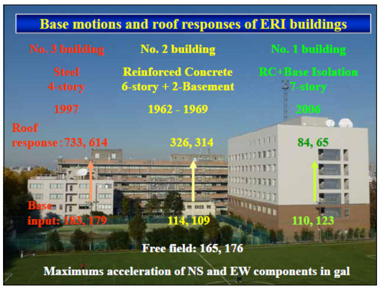
(Slide 15) In recent years, or last several decades, near field earthquakes have become more problematic. Two big near field earthquakes occurred in Kobe and Niigata, which were 2 times to 3 times stronger than the design loadings. Damage caused by such near field earthquakes may be more significant in the field of structural engineering. However, this time, an extremely huge earthquake occurred far away, from 200 kilometers to 400 kilometers off the coast.
(Slide 16) Let me talk about what happed at the University of Tokyo. This is the building of the Earthquake Research Institute. Building No. 2, which has been retrofitted, is over 40 years old. It is made of reinforced concrete.
(Slide 17) Building No. 1 is a base isolated structure. I was in this building. I felt very long and slow motions but was not at all scared.
(Slide 18) Building No. 3 is a steel building and received very characteristic damage
(Slide 19) In these buildings and the surrounding ground, many seismographs are installed and responses of buildings are measured. At the ground surface, ground motions of around 0.2G, or about 165gal or 176 gal, were measured. At the base of RC and base isolated buildings, it becomes nearly halved. This is a phenomenon called input dissipation.

Responses of the upper part of base isolated buildings further decrease. The acceleration response was only around 84gal and people inside were completely safe. However, in the case of RC buildings, the acceleration response increases by around three times, therefore, the response of the upper part of Building No. 2 was around 0.3G. The worst are steel buildings. The input was around 0.2G but the response of the upper part of Building No. 3 was around 0.7G. In the case of the latest earthquake, base isolated buildings showed excellent seismic performance and RC buildings in Tokyo also showed rather good performance. Steel buildings were problematic. Even in Tokyo, rooms on the fourth floor of steel buildings were damaged rather severely. Many of those in Tohoku received even worse damage.
(Slide 20) Now, I will show you damage in Fukushima prefecture.



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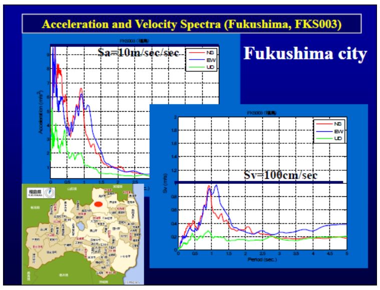

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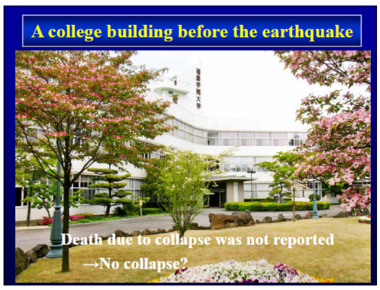

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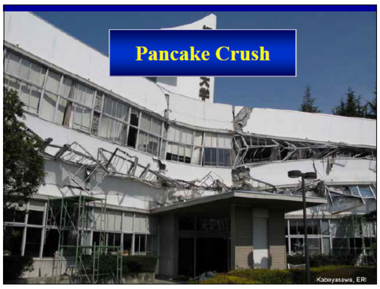

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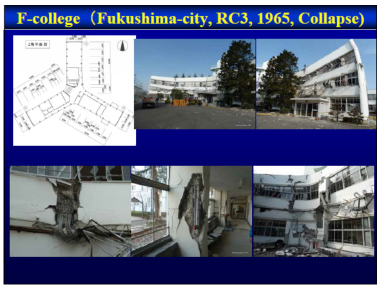


Slide 24

The earthquake was of the level that almost reached the design loadings. The seismic intensity in Fukushima city was around upper 5 to lower 6. (Slide 21) Directly after the earthquake, no casualties in structures were reported. Later, some were reported, but basically, it was announced that no one was killed due to the collapse of structures.

(Slide 22) Still, structures were damaged. This is called Pancake Crush. If people had remained inside, it would have been rather dangerous.

(Slide 23) According to the interviews, the building collapsed like this in two or more minutes after inhabitants felt the ground motions. Therefore, 50 to 60 people inside the building could all escape, and three were confined but rescued later.

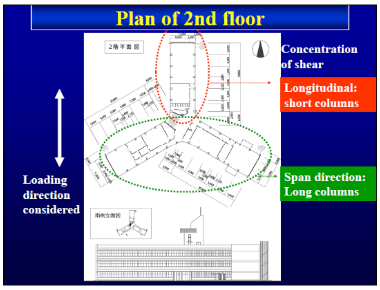
(Slide 24) This building is Y-shaped, which was the cause of such serious damage. The building was old and lacks adequate shear reinforcement.

(Slide 25) It may be a little too much detail, but if an earthquake occurs at this zone in a vertical direction, for example, these become short columns due to influences of retaining walls and hanging walls. These are columns with short deformable height. As retaining walls and hanging walls have no influence in the span direction, these become long columns. The loadings differ completely between short columns and long columns, and short columns first bear the earthquake load or often bear most of the whole load of the earthquake. Such phenomenon is well known, but it occurred at this building by chance in a typical manner.

(Slide 26) This building collapsed as seen in the upper photos. Other buildings had gone through seismic diagnosis and had been retrofitted. The collapsed building was the only one that was left as it was. It was unfortunate.

(Slides 27-28) These are photos of an elementary school in Fukushima city.

(Slide 29) It has long been common knowledge that significant damage is caused by the earthquake load being concentrated on short columns, as was observed in the latest earthquake.



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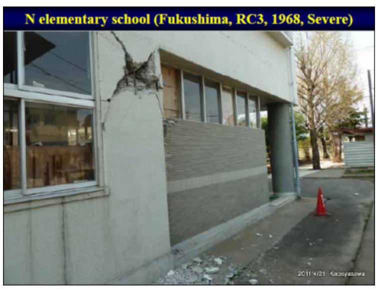

Slide 29


Slide 30

(Slide 30) The damage was also similar.
(Slide 31) This is a kindergarten building, one story high.
(Slide 32) In this building as well, the earthquake load concentrated on short columns of the northern side and walls and columns failed to share the load.
(Slide 33) In the end, the building was severely damaged although the calculated seismic performance index was 0.67, which was close to the required level 0.70.
(Slide 34) This is the present situation of the kindergarten.
(Slide 35) Notable damage was observed at a hall, which is a RC building with steel roof. This is the prefectural cultural center located in the center of Fukushima city. The windows were broken at the RC part.
(Slide 36) However, the structure itself was not so damaged. But as you see, the ceiling fell off. The same happened in wider areas not limited to Fukushima city. More than a year has passed, but this cultural center is still left unrepaired.
(Slide 37) This is another exhibition hall. It is one of the characteristics of the Great East Japan Earthquake that the ceiling fell off not only in old buildings but also in rather new buildings.
(Slide 38) The damage was as serious to a degree that might have caused casualties if there had been people inside. Ceiling design has not been concretely defined as part of structural design, and this should be reviewed.

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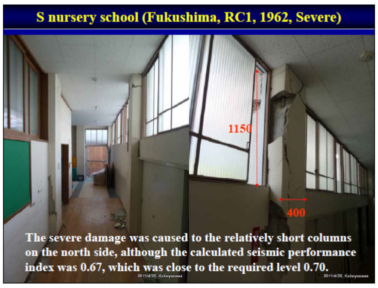

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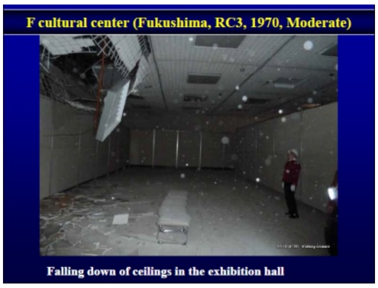

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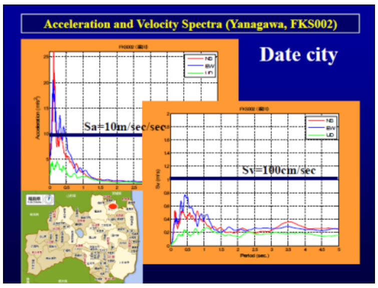

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(Slide 39) This is Date City, located east of Fukushima. The city became famous because high radiation levels were detected.
(Slide 40) This is part of the damage of Date City. The photo shows cherry trees. Date City is known for its production of peaches, but they were also damaged due to the earthquake.
(Slide 41) As you have seen, the intensity of the earthquake was a little bit stronger in Date than in Fukushima, but still it was at the level of lower 6. Damage caused by short columns can be observed on the second floor.
(Slide 42) The building was severely damaged to a level requiring reconstruction.
(Slides 43-44) Such damage was not so common but was observed in several school buildings. Buildings are assessed with the seismic performance index. The calculated seismic performance index was around 0.38 for the aforementioned building that needs to be reconstructed. The index for another building was around 0.47 and this building was only moderately damaged and may be repaired and retrofitted, thus not needing to be reconstructed.
(Slide 45) Damage to gymnasiums was notable this time. Not only old gymnasiums but also new ones were considerably damaged. Please look at the joint part, where steel beams are anchored to the concrete wall.
(Slide 46) This part was pulled hard and part of the concrete fell off.


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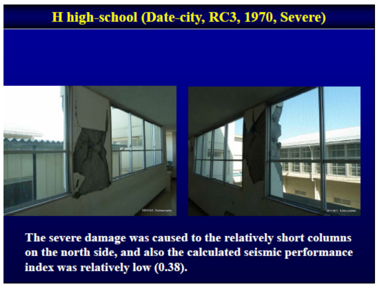

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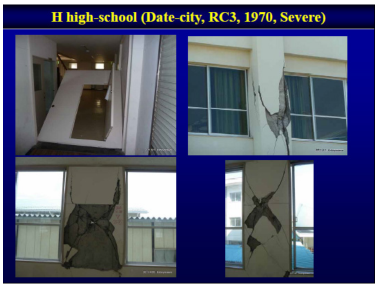

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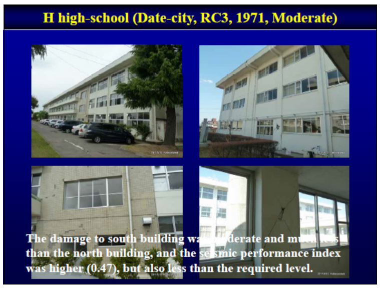

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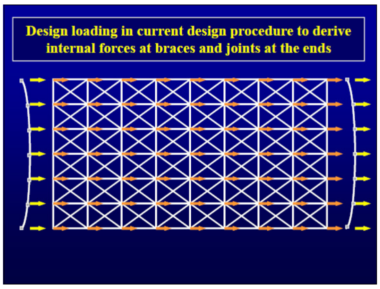

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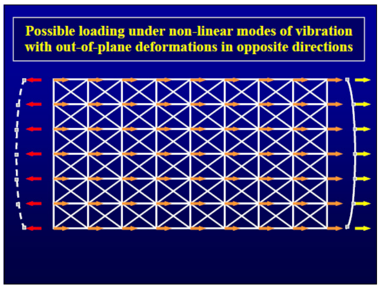

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If this had happened at the time of the first quake, it would be nothing as all people had already escaped. However, the damage was caused by an aftershock on Aril 7, when there were many evacuees in the gymnasium. It was around 11 o'clock at night that concrete fragments fell close to some evacuees that were sleeping. This means there was a possibility for a serious secondary disaster.

(Slides 47-48) I will skip a detailed explanation as it may be too technical, but the force acting on the anchored part is calculated in detail using these models at the design stage.

(Slide 49) I will not explain in detail, but I suspect that the calculation method employed at present is itself insufficient.

(Slide 50) We assume that the earthquake load acts in the same direction, but actually it does not.

(Slide 51) When columns at both ends start to vibrate independently, a kind of pulling force starts to act. However, such phenomenon is not taken into account in the present structural calculation, I think.

(Slide 52) Similar damage was also observed at the time of the Great Hanshin-Awaji Earthquake. There was a case in which the joint part of the edges of the ceiling structure, which was only an overlaid precast concrete roof, not a steel roof, was broken and the ceiling as a whole fell down. Fortunately, the earthquake occurred early in the morning at 5:47 and the accident caused no casualties.

(Slide 53) There still are around 4,000 buildings with a similar structure, including 2,000 in school facilities. These need to be retrofitted as soon as possible. This is a technique imported from a foreign country, the name of which I will not mention here, that is free from earthquakes. The technique was imported including the details concerning joint parts, but when we import foreign techniques of this sort, special attention is required, as in the case of Fukushima Dai-ichi NPP.

(Slide 54) Next, I will talk about the middle part of Nakadori, Fukushima. Around here, in Koriyama and Nihonmatsu, the earthquake load seems to have been larger to the south, not based on records but on the seriousness of the damage. This may be due to the quality of the ground.

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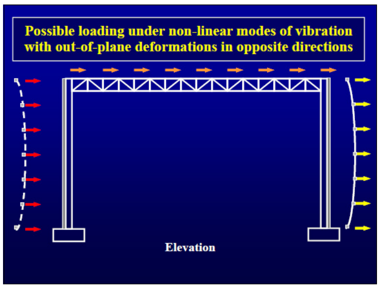

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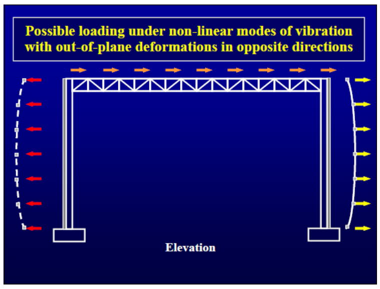

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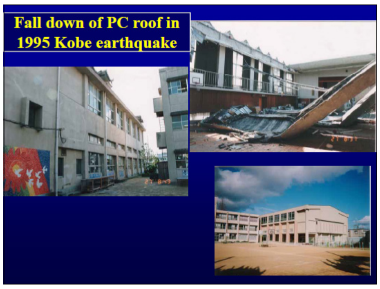

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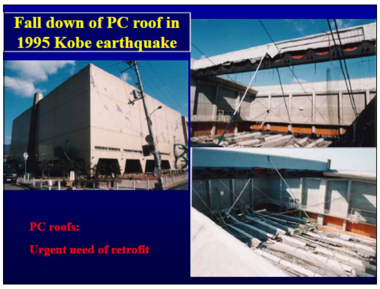

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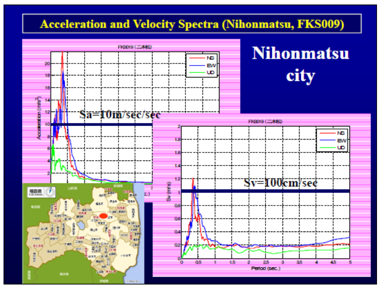


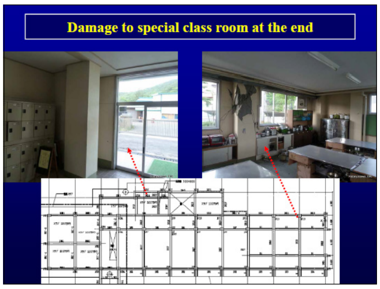
Slide 54

(Slide 55) Some buildings nearly collapsed like this.
(Slide 56) The first floor of this building does not have enough earthquake resisting walls. There should be such walls throughout the first to the third floors, but a somewhat larger staff room needed to be made on the first floor and the first floor does not have earthquake resisting walls though floors above do. As a result, independent columns received too much load and were crushed. We could observe damage whose causes were very clear.
(Slide 57) As in the case of the aforementioned building that lacks enough earthquake resisting walls in the lower floors…
(Slide 58) There are three columns, but when the room at the end of the hall is used as a special class room, which often happens, columns decrease from three to two in number. This is not at all special, but is very common as a design for a special class room. Such buildings are apt to be damaged at these columns.
(Slide 59) Other kinds of damage were all caused by the concentration of the earthquake load on short columns.
(Slides 60-62) Regarding cases in Koriyama, I will focus on the effects of retrofit, earthquake-resistant reinforcement. This building had been partially retrofitted and only part that had yet to be retrofitted was severely damaged.
(Slide 63) Only the east part of this building had been retrofitted in FY2010, but the whole building is structurally continuous.

Slide 55

Slide 56


Slide 57



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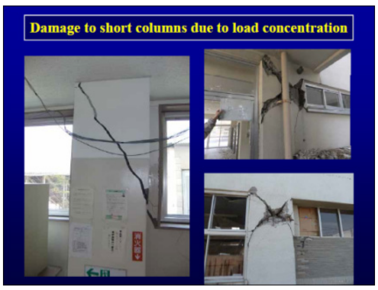

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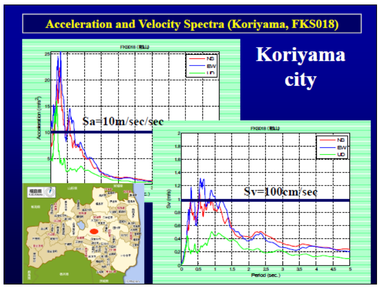

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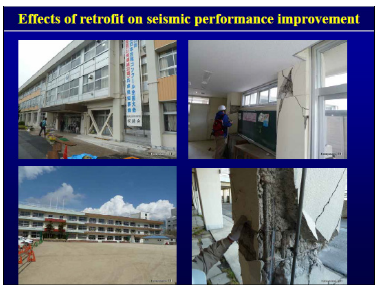

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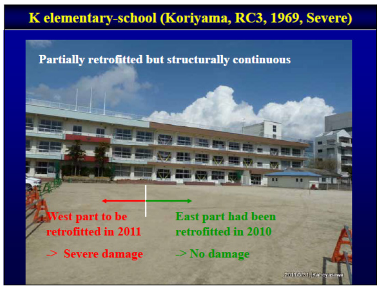

Slide 63

The retrofit work was completed for the east part in FY2010 and the remaining part was to be retrofitted in FY2011. However, the earthquake occurred in March 2011. (Slide 64) The earthquake almost destroyed said remaining part, (Slide 65) whereas; the retrofitted part was scarcely damaged.

This shows that even in the case of a single building only partially retrofitted, the retrofitted part and the remaining part respond completely differently. This may be due to expansion and contraction of the floor. It is necessary to note that complete Floor Rigid Diaphragm Action is unrealistic.

(Slide 66) This is the aforementioned structurally discontinuous building. The retrofitted part was scarcely damaged but the remaining part was destroyed and needs to be reconstructed.

(Slide 67) I also checked this building closely, but the damage was quite minor.

(Slide 68) However, this part not retrofitted was severely damaged.

(Slide 69) This is in Fukushima city. It was proved that rather old buildings, even those over 40 years old, that had been retrofitted with braces or walls showed rather good seismic performance.

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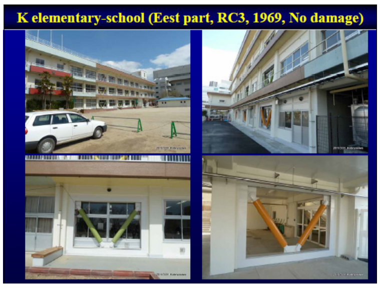

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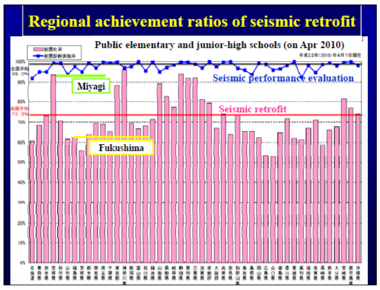

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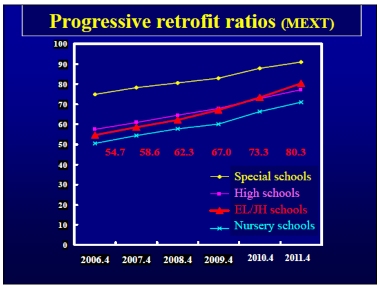
(Slide 70) On the other hand, some retrofitted buildings or those assessed as satisfying certain seismic criteria were, not severely damaged, but rather moderately damaged. They are examples showing an insufficient strength index, but I will not explain this in detail here.
(Slide 71) This building in Tochigi prefecture had also been retrofitted, but only up to the second floor, and its third floor was assessed to be strong enough. However, the first and the third floors were also considerably damaged and the whole building needs to be reconstructed in spite of having been retrofitted partially. Such a case was rather rare but this actually happened.
(Slide 72) Regarding to what extent Japanese schools have been retrofitted, this shows the situation as of April 2010. Those already retrofitted account for nearly 80%, including those that need not be retrofitted in the first place.
(Slide 73) The percentage of retrofitted schools was only 30% around ten years ago but increased gradually by several percent every year, reaching nearly 80% now. At this pace, in several years or in less than a decade, retrofit will be completed for all schools. As was proved in the latest earthquake, retrofitted buildings generally showed excellent seismic performance.
(Slide 74) Looking at the distribution of seismic performance indices of schools waiting for retrofit, around one-fifth of them had a very low index, below half of the required level. Around 20% of old schools have yet to be retrofitted and 20% of them are in danger, being highly likely to collapse in the event of a large earthquake. In the calculation, several percent, or 4 or 5 percent of schools, may receive serious damage.
(Slides 75-77) This is also a typical case of damage to a school building caused by inadequate shear reinforcement and short columns on the north side. (Slides 78-80) A certain number of schools were severely damaged, as there may be one in each municipality.



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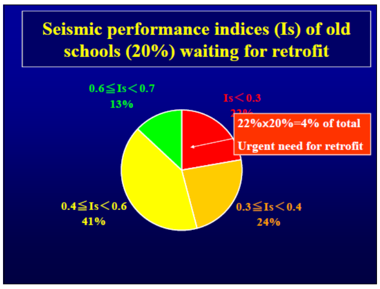

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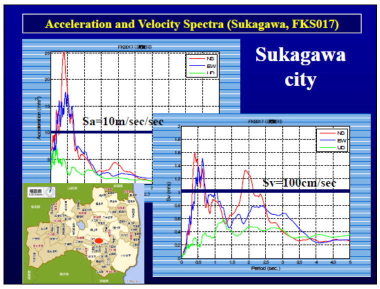

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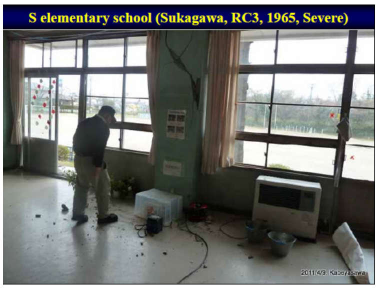

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(Slide 81) This gymnasium was built in 1985. Like this one, some of the gymnasiums that meet the new seismic criteria applicable at present were also moderately or severely damaged.
(Slide 82) The aforementioned damage can be observed again. The part of the concrete where steel beams are anchored fell off.
(Slide 83) I suspect that fundamental problems lie in its design.
(Slide 84) This is another case of damage to a gymnasium. This gymnasium is also new.
(Slide 85) The ceiling was damaged. When the ceiling is damaged in this manner, the gymnasium cannot be used as a shelter or for any other purposes. I heard that nearly 100 gymnasiums were damaged at the ceiling like this. Especially in Fukushima, they had difficulties in securing enough shelters or reopening schools due to such damage to gymnasiums. Those gymnasiums have yet to be repaired, I think.
(Slides 86-87) This is a public hall. From outside, the building seems to be undamaged, but was actually moderately damaged.
(Slide 88) The third floor is the municipal assembly hall. Steel beams were bridged over a large span, and the edges thereof were broken, which caused the ceiling to collapse.
(Slide 89) The joint parts of the beam edges were broken and the ceiling fell down. (Slide 90) Ultimately, the hall cannot be used any longer.

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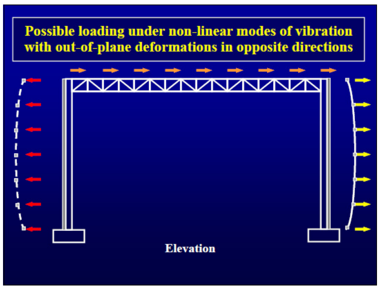

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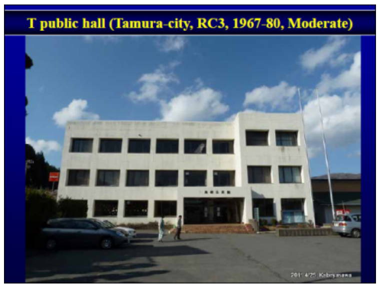

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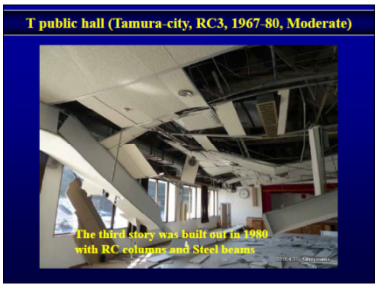
The first floor and the second floor were also affected somehow. (Slide 91) As shown in cross section, steel beams were bridged here and maybe this column and this column… As a precast concrete floor was just overlaid, extremely huge force may have concentrated on the bolt at this edge.
(Slides 92-97) Similarly in Shirakawa, one or two buildings were moderately or severely damaged. This building was constructed in 2008, only three years ago, and is assessed to have received minor damage. However, in the end, the building cannot be used any longer. It is made of reinforced concrete but has a mixed structure with wooden roof and beams as well as steel braces.



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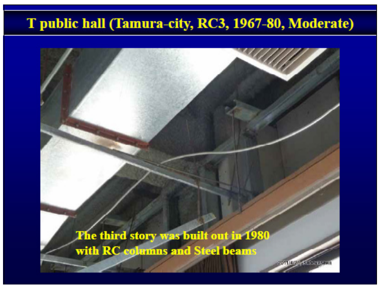

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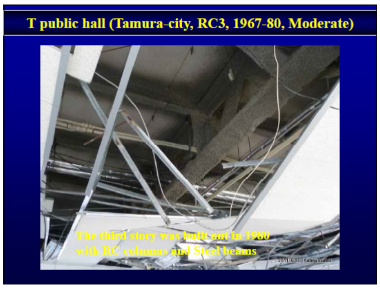

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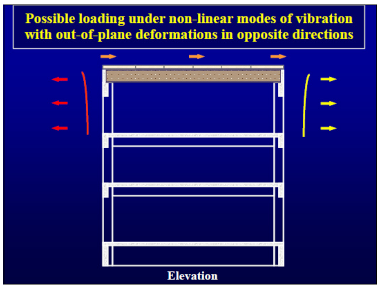

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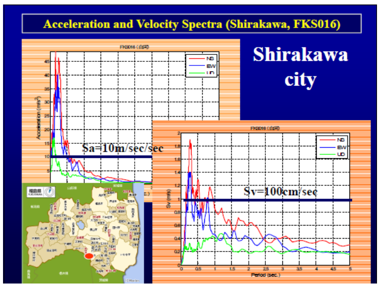

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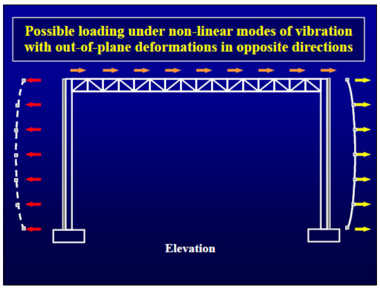
(Slide 98) As a design, such structure would be very stylish or beautiful, but the edge parts will be extensively damaged. You have to note that responses to an earthquake are completely different in a building with a mixed structure, compared to those where floors are fastened with reinforced concrete.
(Slide 99) You need to understand that it is very difficult to design such a building.
(Slide 100) You cannot design and construct any building by merely ensuring that the current criteria are satisfied in a simple stress analysis.
(Slide 101) Next, this is Hamadori. (Slide 102) The damage was caused by the tsunami. Many buildings were damaged by the tsunami also in Fukushima Prefecture.
(Slide 103) Damage caused by the tsunami accounted for a larger percentage.
(Slide 105) This school is located at around 3 kilometers from the seashore, but almost all wooden houses around the school were swept away. (Slide 104) The stain on the wall shows that the height of the tsunami was around 2 meters. Similar evidence could be found at other places as well.
(Slides 106-107) It may be in Iwaki city that the ground motion was the strongest in Fukushima prefecture. The third asperity or the third epicenter was as near as 50 kilometers off the coast, and the city received extremely strong motions, which were close to those caused by near field earthquakes and had a rather long frequency of around one to two seconds.



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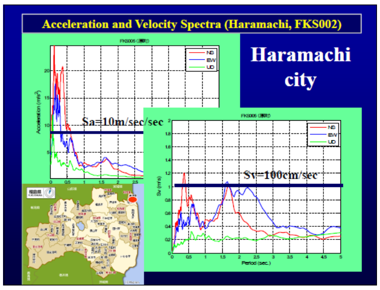

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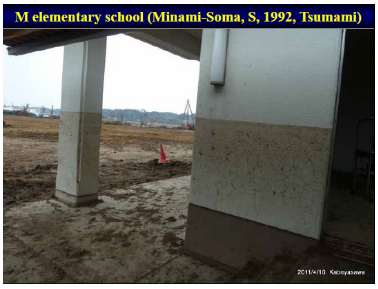

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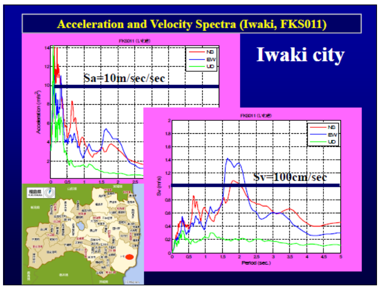

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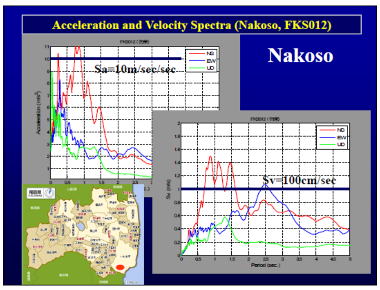

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(Slide 108) This is the only building severely damaged among those constructed after 1970.

(Slide 109) This is a RC building located on a hill that is around 30 meters in height. It is assumed that ground motions were amplified due to the land form. This is a rather unique case.

(Slide 110) This is a gymnasium considerably damaged although it had been retrofitted.

(Slide 111) The upper structure had been retrofitted, but the foundation was uneven, mixed with pile foundation here and spread foundation in the center. As a result, the spread foundation part subsided also partially due to liquefaction. (Slides 112-113) Accordingly, the upper structure was subject to forced deformation and the whole building bent.

(Slide 114) On the contrary, no serious damage has been reported basically in Aizuwakamatsu city, where only minor damage was observed. However, ground motions were not necessarily weak but were recorded at the same level as those in Fukushima city. This is because in snowy regions, such as Aizu and Niigata, estimated snow load is included in the earthquake load in designing and buildings are constructed on a rather high level based on severer design loadings, as you may generally recognize. Consequently, there was no serious damage. Ground motions may have been a little bit weaker in reality, but it is considered more attributable to better seismic performance of buildings unique to the snowy region.

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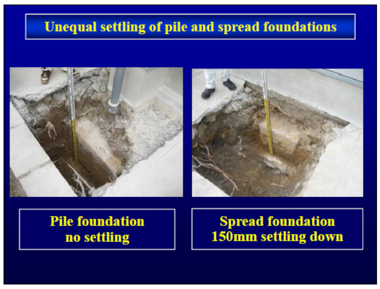

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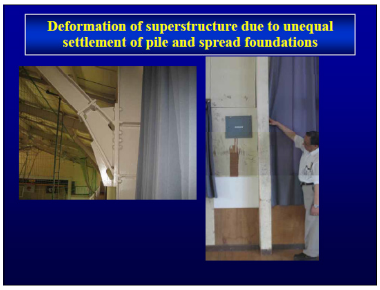

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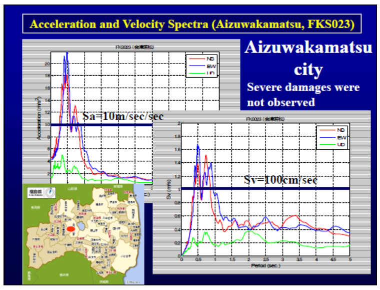

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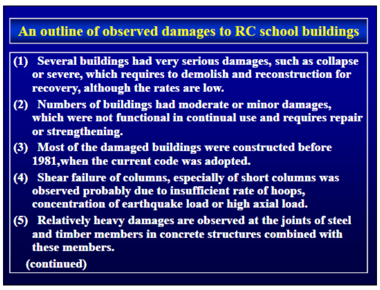

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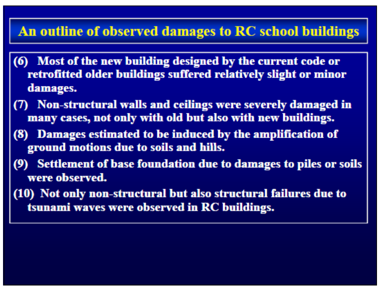

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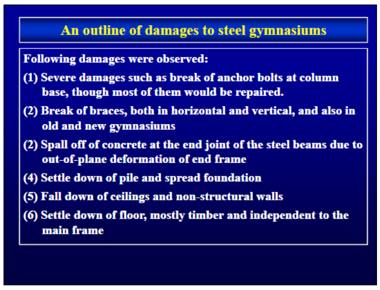

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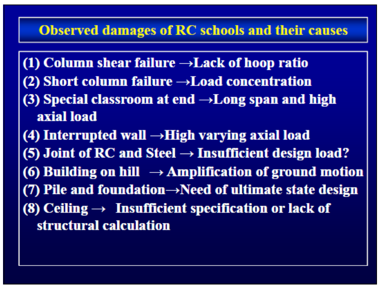
(Slides 115-118) This is what we have learned concerning the outline of damage. (Slide 119) What I would like to stress most strongly is that structural designing or structural plans should not only focus on ensuring that buildings do not collapse with ground motions at the level currently presumed, but should place importance on assuring their post-earthquake functionality. Any damage even in design of non-structural elements may make the building unusable for over a year and will cause inconvenience. If we know what cannot be used after an earthquake, in advance, that would not cause so much trouble, but actually unusable buildings are found one after another. It is the same for new buildings. One of the problems to be coped with in the future is how to ensure that buildings will remain usable even after an earthquake.
(Slide 120) I think that we need to study it.
(Slide 121) This is vibration testing by E-Defense. We also intend to conduct various experiments of this sort, but MEXT has not been so interested. This involves some complicated matters concerning the vertically-divided administration, as these are under the jurisdiction of the Science and Technology section, not of the Educational section. (Slide 122) Anyway, I would like MEXT to actively promote these experiments and studies. I have sufficiently conducted my own research so far, so I expect that young people will take the initiative.
(Slide 123) While it seems that we already know about seismic disasters, there still are many that have not been made clear. This is the results of the investigation in Miyagi prefecture conducted after the earthquake. As you see, the correlation between damage and seismic performance of buildings varies widely.
(Slide 124) This is the results of the complete survey targeting 4,000 buildings at the time of the earthquake in Kobe in 1995. Even these results have yet to be fully analyzed and there remain questions. However, it has been considered OK as the actual damage was smaller than the analysis results, but the reasons for concluding that it is OK have not been clarified.
(Slide 125) This roughly shows damage rates regarding prefectural high schools in Fukushima, as there was a list of prefectural high schools, although the total number of schools in the prefecture was unknown. Damage rates were around 7% to 10% of the total. If limited to schools constructed from 1981, the rates of those sustaining minor or more severe damage were around 10% to 15%. These figures are within the presumed level in line with our experience and are not obtained through calculation. Calculated damage rates would have been larger.



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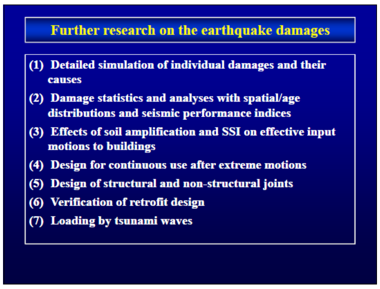

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(Slide 126) This shows the correlation between damage and seismic indices at the time of the Great Hanshin-Awaji Earthquake. An exceptional correlation can be observed here. (Slide 127) I studied the causes thereof in various ways after the earthquake, but I will skip the explanation.

(Slide 128) In the case of the Great East Japan Earthquake, seismic indices had been calculated for most of the buildings and the correlation between those indices and seismic damage has been available rather in detail. Therefore, we have to analyze those available data precisely. I think a preliminary report on the damage caused by the Great East Japan Earthquake will be compiled in March 2012. We need to spend years to further analyze them.

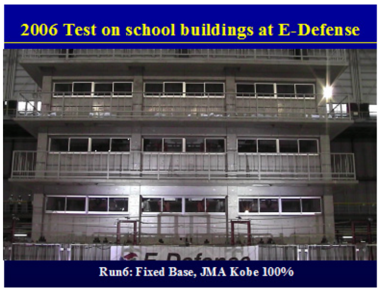
(Slide 129)

(Applause)

Moderator:

Thank you very much, Professor Kabeyasawa.

Lastly, Mr. Fukuei Saito, Director of the Educational Facilities Research Center of the National Institute for Educational Policy Research, will give a closing address.



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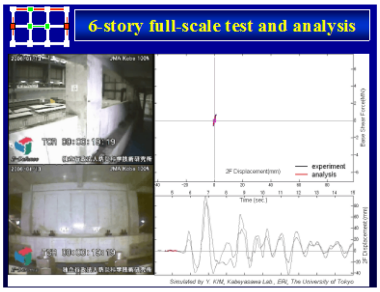

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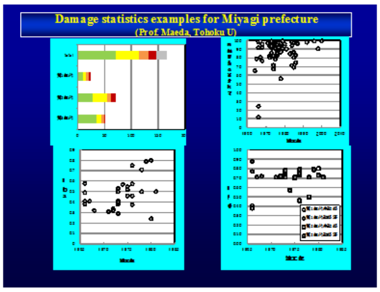

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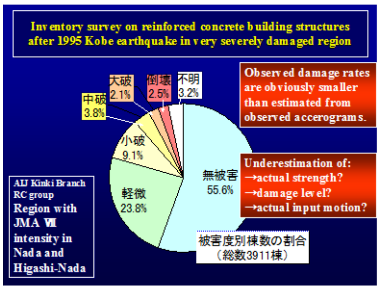

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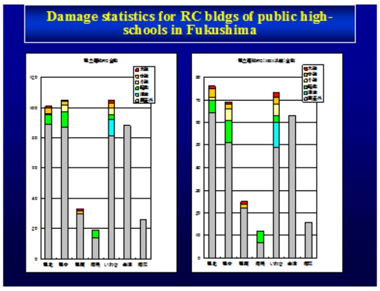

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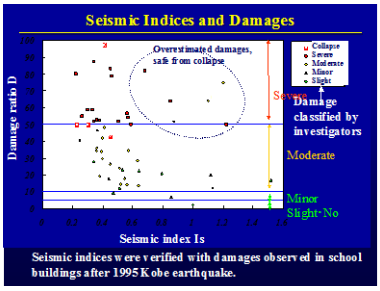

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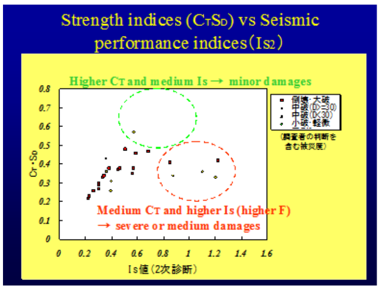

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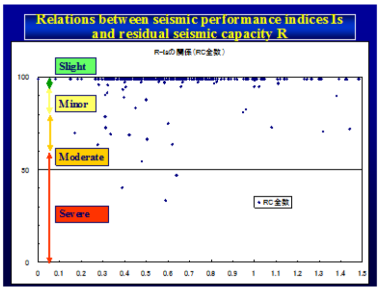

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III. Closing Address

Closing Address

Fukuei Saito
Director of the Educational Facilities Research Center
of the National Institute for Educational Policy Research

Thank you very much for attending today's Seminar on Educational Facilities Research. I appreciate your attentiveness for many hours.

The earthquake that occurred in New Zealand in 2011 was covered by the Japanese media as well. New Zealand is well known as a country with advanced earthquake-resistant technology and the damage caused by said earthquake attracted the attention of experts, but available information was rather limited compared with that for earthquakes in Japan. It was a precious opportunity for us to listen to a lecture comprehensively explaining measures of earthquake resistance of school facilities and reconstruction efforts in New Zealand from Ms. Kim Shannon and Mr. Wayne Tacon. This will be a great help for our efforts in the future.

Professor Ueno lectured us on the situation of schools used as emergency evacuation sites at the time of the Great East Japan Earthquake and on problems thereof, based on an abundance of data. Thank you very much. Professor Ueno strictly pointed out that we have failed to draw lessons from past earthquake disasters. I think it is extremely important to consider means to enhance disaster prevention functions of school facilities nationwide.

Professor Kabeyasawa explained the structure and safety of school buildings in detail, based on the results of the investigation and post-earthquake evaluation by MEXT and from an academic viewpoint. Professor Kabeyasawa stated that earthquake-resistant measures we have promoted were proved to be effective, while pointing out many problems, such as those concerning aseismic work for non-structural elements and designing for rare cases.

I think that we, who live in earthquake-prone countries, are required to make constant efforts for countermeasures against earthquakes. As we learned today about the changes in seismic criteria in New Zealand, we have accumulated knowledge based on efforts made by our predecessors and from each of the earthquakes we have experienced, step by step. It is the duty for all related parties, including all of us gathered here, to learn lessons from the recent disastrous earthquakes that occurred in New Zealand and Japan and promote further efforts for enhancing security and safety of educational facilities. It would be our great pleasure if this seminar would contribute to promoting such efforts.

Lastly, I would like to extend my profound gratitude to all the speakers, Ms. Kim Shannon, Mr. Wayne Tacon, Professor Jun Ueno, and Professor Toshimi Kabeyasawa. Thank you very much. This concludes today's seminar. Thank you very much.

(Applause)

Moderator:

This concludes the FY2011 Seminar on Educational Facilities Research by the National Institute for Educational Policy Research. Thank you for your kind cooperation.

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