Making Schools Resilient at Scale: the Case of Japan

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Abbreviations

AIJ	Architectural Institute of Japan
BOE	board of education
CDMC	Central Disaster Management Council
FDMA	Fire and Disaster Management Agency
Is	seismic index of structure
JBDPA	Japan Building Disaster Prevention Association
MEXT	Ministry of Education, Culture, Sports, Science and Technology
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
PFI	private finance initiative
RC	reinforced concrete

Executive Summary

Japan's Program for Earthquake-Resistant School Buildings has increased the seismic safety of Japanese schools, and hence increased the safety of Japanese schoolchildren, teachers, and communities. Since 2003, when the program accelerated, the share of earthquake-resistant public elementary and junior high schools has increased, from under half of schools in 2002 to over 95 percent in April 2015.

Japan is sharing knowledge from this program with developing countries through its relationship with the Global Facility for Disaster Reduction and Recovery (GFDRR), whose **Global Program for Safer Schools** has been supported by the Japan–World Bank Program for Mainstreaming Disaster Risk Management in Developing Countries and its implementing arm, the **Disaster Risk Management Hub, Tokyo**.

Although it is known for its technology- and engineering-driven solutions to disaster risk management, Japan has also had significant experience devising nontechnical solutions that meet institutional, legal, and financial challenges. Japan's ongoing efforts to mitigate earthquake risk and improve the seismic safety of schools involve learning from the experience of earthquakes, advancing engineering knowledge and technology, accumulating data, and exercising the political will to pass relevant legislation and secure funding. Lessons from Japan should prove useful to countries that are considering embarking on their own retrofitting programs.

Context for the Program for Earthquake-Resistant School Buildings

Located in the circum-Pacific mobile belt, where seismic and volcanic activity occurs constantly, Japan is highly exposed to earthquake hazard. To address this exposure, Japan began to include seismic design in its building regulations close to a century ago. The first Japanese building standards to include seismic design were issued in 1924, after the Great Kanto Earthquake of 1923. Since then, building standards have been revised after every major earthquake. The latest major revision of building standards took place in 1981 and incorporated a new seismic design method. Accordingly, buildings that are built after 1981 are deemed earthquake-resistant, but those built before 1981 need to be evaluated for their seismic capacity based on the 1981 standards.

In addition to building regulations that include seismic standards, Japan has developed standards for seismic evaluation and guidelines for seismic retrofit of existing buildings. Guidelines for existing reinforced concrete (RC) buildings were issued in 1977, followed by guidelines and standards for steel structures (1979), wood structures (1979), and steel-reinforced concrete structures (1986). They are periodically revised to accommodate revisions of building standards.

Program overview

In Japan, making schools earthquake-resistant has been a long-time effort of both the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and local governments. Municipal governments have managerial and financial responsibility for making school facilities safe; but they rely on standardized guidance and financial subsidies from MEXT and prefectural governments.

Under the Program for Earthquake-Resistant School Buildings, MEXT sets policies, arranges financial schemes, and provides technical guidance in the design phase, while municipalities develop plans for implementing school retrofitting and realize them with the support of prefectural governments and the national government (see figure ES.1). The program seeks to ensure that existing school buildings are earthquake-resistant. RC school buildings constructed under the 1981 building standards are considered earthquake-resistant, while those built before 1981 must be evaluated and then retrofitted if the seismic capacity does not meet the standards.

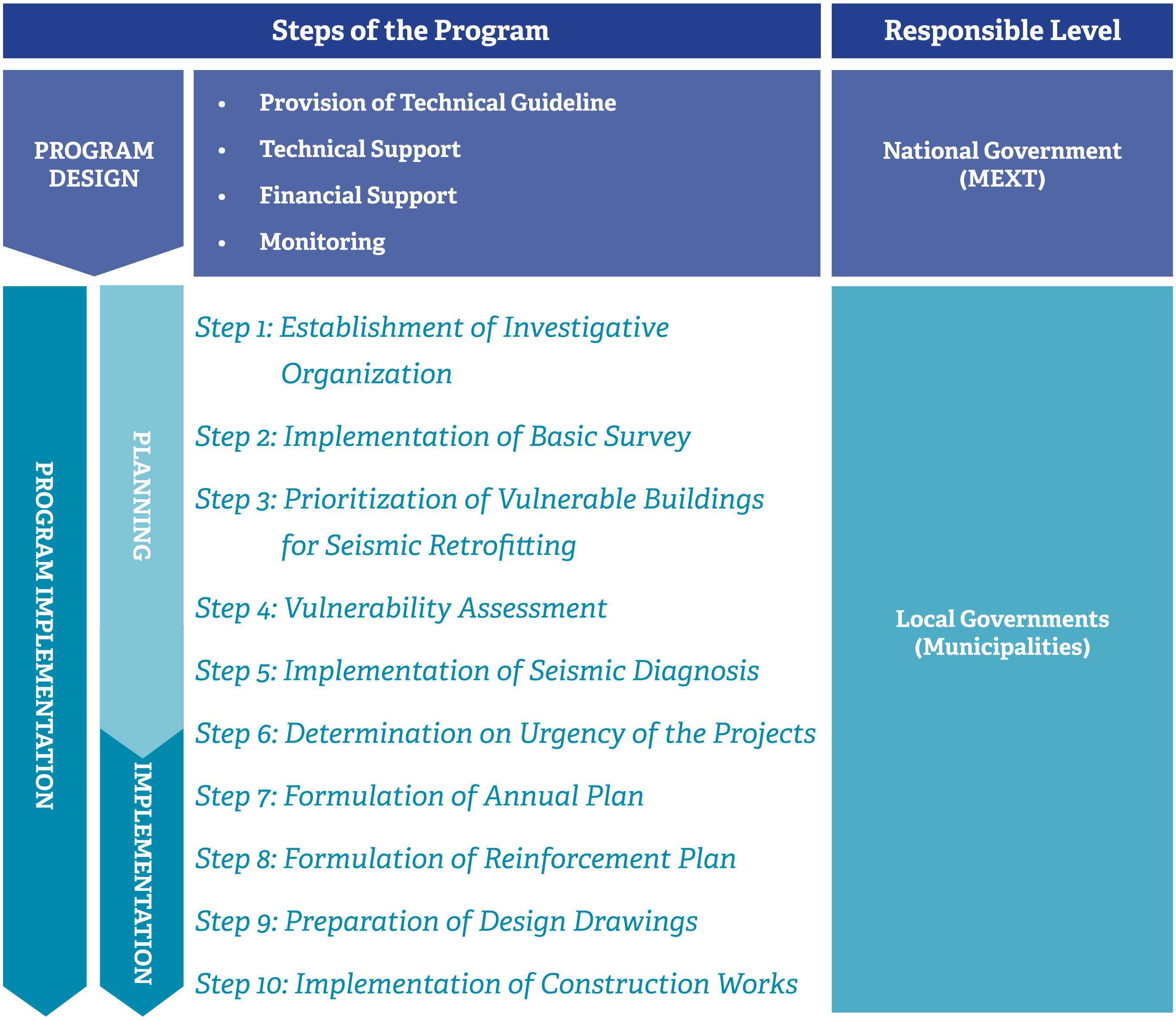


FIGURE ES.1

Steps of the program and responsible government level

The national government's initiative for making schools earthquake-resistant was introduced in 1978. Its focus was reconstruction and seismic retrofitting of public elementary and junior high schools in the Tokai and southern Kanto regions, where earthquake risk was considered high. But the 1995 Great Hanshin-Awaji Earthquake affected a different part of the country, one with comparatively low levels of earthquake preparedness. In response to this event, which damaged over 3,800 schools, MEXT commissioned the Architectural Institute of Japan to survey the seismic capacity of education infrastructure. The results showed that damage was concentrated in buildings built before 1981, and that the intensity of damage depended on the seismic capacity of individual buildings. In 1995, subsidies for seismic retrofitting, which had been limited to the Tokai area, were extended to the entire nation, and in 1996 MEXT urged local governments to enhance schools' earthquake resistance through seismic diagnosis and retrofitting.

Two surveys conducted in 2002 showed that local governments were responding very slowly. A Fire and Disaster Management Agency survey found that only 31 percent of school buildings constructed with pre-1981 standards had completed the seismic diagnosis, and only 46 percent of all school buildings that have a function of evacuation centers had satisfied the required seismic capacity as of April 2002 (FDMA 2002). Alarmed, MEXT surveyed all public elementary and junior high schools in the nation and got a similar result: 31 percent of the 88,000 school buildings built before 1981 had completed the seismic diagnosis, and only 44.5 percent of all existing school buildings and facilities had been confirmed as earthquake-resistant.

MEXT then convened an expert group to study earthquake resistance in school facilities and develop concrete measures for local governments. Based on the group's findings, MEXT issued the "Guidelines for Promotion of Earthquake-Resistance School Building" (MEXT 2003). The guidelines, which marked the acceleration of the Program for Earthquake-Resistant School Buildings, called on local governments to (1) prioritize schools with the worst seismic capacity, (2) diagnose schools promptly and accurately, (3) publicize findings, (4) inspect and where necessary improve nonstructural elements, (5) carry out general and earthquake-resistance improvements simultaneously, and (6) promptly formulate a plan to promote earthquake resistance.

As a result of the program, the share of earthquake-resistant public elementary and junior high schools has significantly increased. In 2002, earthquake-resistant schools accounted for 44.5 percent of the total; in April 2015 they accounted for 95.6 percent (figure ES.2). By March 2016, the target date for completion of the work, the share is expected to have reached about 98 percent. (For the remaining 2 percent of buildings, seismic retrofitting or reconstruction has had to be postponed due to the planned consolidation or closure of the schools.) Since 2003, approximately 52,000 buildings have been confirmed earthquake-resistant by seismic diagnosis or seismically improved by seismic retrofitting or reconstruction.

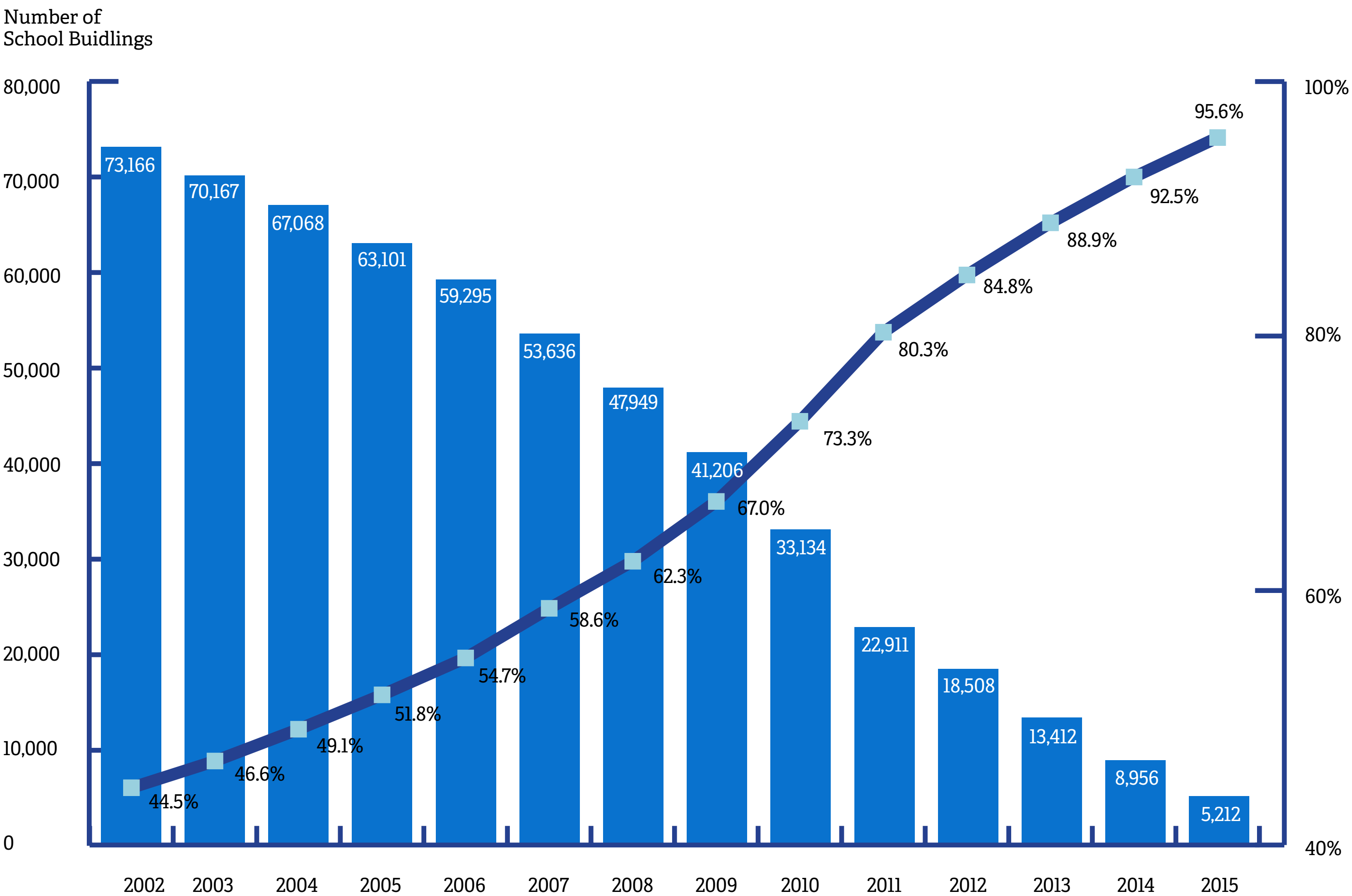


FIGURE ES.2

Share of public elementary and junior high schools whose main structures are earthquake-resistant

Source: MEXT 2015b.
Note: The data are as of April for each year.

MEXT has also made progress in ensuring the safety of nonstructural elements, which can cause potentially fatal injuries. As early as 2002 it developed a relevant guideline, and in 2008 it began preparing the national subsidy. Since the 2011 Great East Japan Earthquake, when MEXT prioritized suspended ceilings in gymnasiums (non structural) , there has been significant progress in this area. As of April 2015, 85.5 percent of school ceilings were considered safe (including gymnasiums without a suspended ceiling), and 93 percent of schools had conducted the inspection for major nonstructural elements.

To fully understand the program's evolution and achievements, it is important to recognize certain key factors that drove or facilitated its development and promotion:

The experience of earthquakes. The 1995 Great Hanshin-Awaji Earthquake revealed the poor earthquake resistance of pre-1981 buildings, and helped to trigger the development of MEXT's comprehensive guidelines. The 2004 Chuetsu Earthquake increased the nascent program's momentum. The May 2008 Sichuan (China) Earthquake, which caused the collapse of 6,898 school buildings (Minemura 2008) and the deaths of 19,065 schoolchildren, drove Japanese politicians and MEXT officials to pass the revised Act on Special Measures for Earthquake Disaster Countermeasures, which provided more money for school retrofitting and reconstruction and increased the role of local governments. Finally, the 2011 Great East Japan Earthquake induced the program to give higher priority to nonstructural elements and highlighted the need for tsunami countermeasures and functional improvement of schools as evacuation centers.

The accumulation of engineering research and practices. Relevant engineering research and practices include a prototype RC school building developed in 1949, whose wide adoption has made retrofitting of schools fairly standardized and hence efficient. They also include the development of standards for seismic evaluation and guidelines for seismic retrofit of existing buildings. These grew out of a pilot program in Shizuoka Prefecture, where large scale earthquake risks have long-recognized, and have been used throughout Japan to promote seismic retrofitting efforts under the Program for Earthquake-Resistant School Buildings.

The availability of data, specifically data on schools, on damages caused by past earthquakes, and on hazard risks. The Program for Earthquake-Resistant School Buildings was begun because survey data showed schools' poor seismic capacity and government's slow efforts to address it. Ongoing annual school surveys conducted by MEXT—the School Basic Survey, Public School Facilities Survey, and the Status of Seismic Resistance of Public School Facilities—provide the basic school infrastructure inventory and make it possible to monitor program progress. Data on damage to building, which are collected by the earthquake damage investigation, are used to direct policy. Finally, data on earthquake risk are used by the national government to prioritize necessary actions, and have been incorporated in laws to promote risk mitigation.

The political will to carry out the program. Promoting schools' seismic safety has been popular among politicians, i.e., members of the Diet, for both humanitarian and economic reasons. In a culture that prioritizes human life, a policy for making schools earthquake-resistant has the noble aim of saving the lives of schoolchildren. The policy also is considered an effective investment that contributes to local economies and produces tangible results that are well-received by the public. Thus the major political parties have supported acceleration of school retrofit and helped to secure the budget for the purpose.

Program design and the role of the national government

Through MEXT, the national government is responsible for directing and supporting local governments' implementation of school retrofitting projects. MEXT provides technical support, prepares financial measures, and monitors projects' progress.

MEXT lays out the basic principles of school retrofitting, including how to use the results of seismic diagnosis to prioritize vulnerable buildings and judge the urgency of retrofitting, in the "Guidelines for Promotion of Earthquake-resistance School Building" (MEXT 2003). The guidelines include seven planning steps for prioritizing the most hazardous buildings:

- *Step 1: Establish an investigative organization.* This group serves as a steering committee to lead activities.
- *Step 2: Implement the basic survey to get information about schools.*

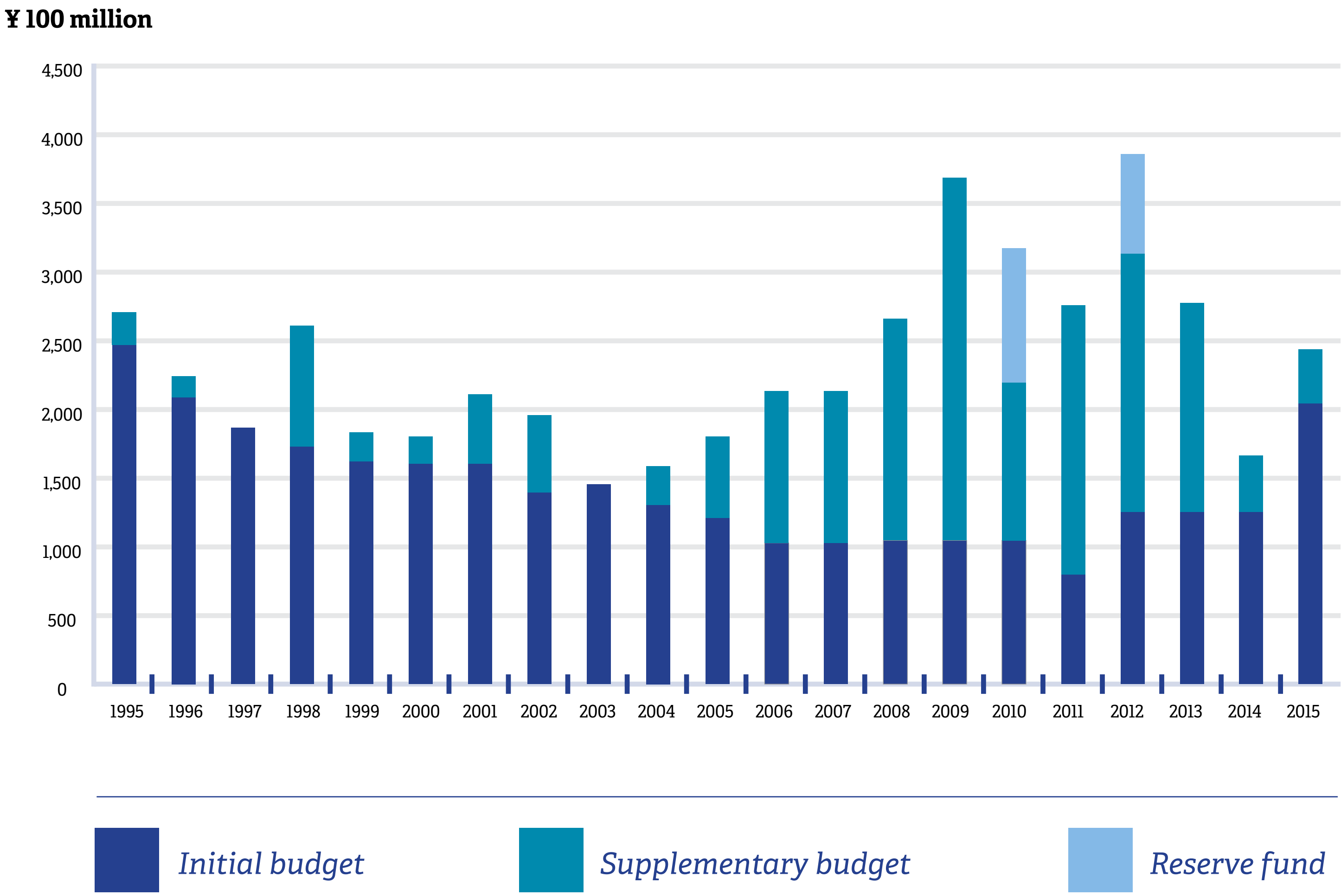
- *Step 3: Conduct a survey to prioritize vulnerable building for seismic retrofitting.* The survey is carried out for RC buildings and structural steel–framed gymnasiums. For the former, the survey uses engineering principles that account for year of construction and number of floors as well as corrections such as concrete strength, degree of aging, floor plan, wall alignment, and assumed seismic intensity. For the latter, it accounts for items earthquake resistance of steel bracings, corrosion rate of steel members, existence of buckling, weld quality, structural safety, nonstructural safety regarding fall prevention, and assumed seismic intensity.
- *Steps 4 and 5: Conduct vulnerability assessment (Step 4) and seismic diagnosis (Step 5).* Depending on the results of the prioritization survey, either a vulnerability assessment or seismic diagnosis is conducted. Vulnerability assessment determines the degree of buildings' deterioration based on structural strength, the deterioration of strength due to aging, and impacts of locational conditions. Seismic diagnosis judges the degree to which a building can withstand an earthquake from the perspective of structural dynamics. When the strength of concrete is low or reinforcing steel and structural steel are widely corroded, and when the likelihood of reconstruction is high, a vulnerability assessment is conducted. When a building is in average or above average condition, seismic diagnosis is conducted without vulnerability assessment.
- *Step 6: Determine urgency.* The priority of projects is determined by the investigative organization and its subgroup of experts based on schools' earthquake resistance. The urgency levels for RC school buildings, structural steel–framed gymnasiums, and gymnasiums with light precast concrete roofs are determined separately. To decide which school facilities among each type should be prioritized, the investigative committee reviews results of the seismic diagnosis for each facility and considers each facility's specific needs.
- *Step 7: Formulate annual plan.* Using the list of school facilities to be reconstructed or retrofitted, local governments formulate an annual plan for implementing construction.

Local governments make the decision about whether to reconstruct or retrofit schools. Reconstruction is recommended when the seismic diagnosis finds low earthquake resistance capacity, when the building receives a low score on the vulnerability assessment, when significant reinforcement is needed, or when the retrofit construction would be extremely difficult. Local governments also make decisions about which method to use for seismic retrofitting (steel-frame bracing, RC shear wall, etc.) based on the type of structure, condition of the building, duration of the construction, costs, etc.

MEXT supports this work by producing retrofitting manuals and by collecting examples of work on different types of structures to serve as references for local governments. It also organizes workshops and meetings to disseminate information to governors, holds technical trainings by academics, and operates a consultation desk to respond to inquiries about promoting earthquake-resistant school facilities.

In addition to offering technical support, MEXT has also arranged several financing measures for school retrofitting and reconstruction:

- *National subsidies for seismic retrofitting and reconstruction* cover the national governments' share of the projects. This share has been raised to two-thirds for retrofitting and one-half for reconstruction. (This is a time-limited measure, but the period has been extended repeatedly and currently expires in 2021). The subsidies prepared for the program were part of MEXT's school facility development budget. As shown in figure ES.3, this budget had decreased before the program started due to the gradual decrease in the number of schools. After the acceleration of the program in 2003, the total budget increased dramatically year by year. As local governments' demands for national subsidies for school retrofit increased, MEXT had trouble securing sufficient amounts in the initial budget. Figure ES.3 shows that the budget increases were mainly covered by the supplementary budgets (the teal bars).
- *Local government bonds and local tax allocation also fund the school retrofitting and reconstruction. For these projects, local tax allocation covers 80 percent of the costs, which makes the actual financial burden on municipalities relatively small.*
- *Private finance initiatives (PFIs) for seismic retrofitting of public schools* were a response to regional disparities in the progress of school retrofitting. PFI was meant to cope with limited financial resources, a large number of buildings needing retrofit or reconstruction, and a lack of local government engineers. In practice, few municipalities used PFI, mainly because unfamiliarity with the scheme made municipalities hesitant to adopt it, and in part because urban municipalities had already retrofitted most of their schools by the time MEXT issued the manual explaining its use.



Source: MEXT 2015a.

Note: The budget includes the costs for kindergartens and special needs schools.

FIGURE ES.3

Facility development budget for public elementary and junior high schools

MEXT has closely monitored the progress made under the program. Using quantitative and qualitative information collected from local governments, MEXT determines the overall progress of the program and takes necessary measures in response. For example, when many local governments initially made slow progress, MEXT tried to identify common problems and to provide solutions (alternative financial schemes, practical manuals, seminars). MEXT has also ranked municipalities by the percentage and the number of earthquake-resistant schools, and publicized this information—an approach that has encouraged lagging municipalities to work more quickly. Such careful monitoring and feedback by MEXT has played an important role in promoting the program.

Program implementation and the role of local governments

Program implementation is carried out at the local level. Prefectural governors guide the municipal mayors in applying the national subsidies, provide technical support to mayors, collect program data from municipal governments and report the results to MEXT, and carry out seismic retrofitting of high schools and prefectural universities.

The municipal governments carry out the seven planning steps for prioritizing school buildings, as described above. They are also responsible for the three steps of program implementation that follow planning: formulating a seismic reinforcement plan to identify possible seismic retrofitting construction methods (*step 8*); preparing design drawings that specify appropriate construction methods, schedules, and costs (*step 9*); and implementing the seismic retrofitting construction works using building contractors (*step 10*). In most cases, the steering committees outsource these three steps to the private sector (architectural and construction firms), though the committees are responsible for both technical and administrative management.

Phase	Procedures of School Retrofitting Program Planning and Implementation	General Affairs Dept., Board of Education	Architecture Dept., Municipal Govt.	(Association of) Architecture Firms	Construction Confirmation Firms (3rd Party)	Schools/ Community
PLANNING	*Step 1: Establishment of Investigative Organization*	Involved	Partially Involved	Partially Involved	Not Involved	Not Involved
PLANNING	*Step 2: Implementation of Basic Survey*	Involved	Partially Involved	Partially Involved	Not Involved	Not Involved
PLANNING	*Step 3: Prioritization of Vulnerable Buildings for Seismic Retrofitting*	Partially Involved	Involved	Involved	Involved	Not Involved
PLANNING	*Step 4: Vulnerability Assessment*	Partially Involved	Involved	Involved	Involved	Not Involved
PLANNING	*Step 5: Implementation of Seismic Diagnosis*	Partially Involved	Involved	Involved	Involved	Not Involved
IMPLEMENTATION	*Step 6: Determination on Urgency of the Projects*	Involved	Partially Involved	Not Involved	Not Involved	Partially Involved
IMPLEMENTATION	*Step 7: Formulation of Annual Plan*	Involved	Partially Involved	Not Involved	Not Involved	Not Involved
IMPLEMENTATION	*Step 8: Formulation of Reinforcement Plan*	Partially Involved	Involved	Involved	Partially Involved	Partially Involved
IMPLEMENTATION	*Step 9: Preparation of Design Drawings*	Partially Involved	Involved	Involved	Partially Involved	Partially Involved
IMPLEMENTATION	*Step 10: Implementation of Construction Works*	Partially Involved	Involved	Involved	Partially Involved	Partially Involved

Involved · *Partially Involved* · *Not Involved*

General Affairs Dept., Board of Education

- *Takes initiatives for the program at municipality level*
- *Responsible for managing all school retrofitting projects, inclusive of fundraising and allocation*
- *Might ask support from Architect Dept. for technical procedures*

Local Governments

- *Responsible for technical assessments and arranges contracts with architectural firms*
- *Close communication with General Affairs Dept. of BOE*

Source: Based on interviews with local governments by the survey team (2016).

FIGURE ES.4

Responsibilities of local governments and other local stakeholders for program planning and implementation

The general affairs department of the municipal board of education (BOE) takes the initiative for planning and implementation and coordinates the stakeholders involved. The general affairs department has administrative staff, but its technical staff is often limited, so it sometimes seeks support from the municipal architectural department.

The steering committee tries to minimize the effect of construction on school activities, so much of the work is scheduled for the summer vacation in July and August. Done on this schedule, projects can take half a year to several years, depending on the type of work; but they are planned to take as little time as possible.

Project costs are estimated using a standardized nationwide price list for cost estimation to ensure fairness in the bidding process. Bids for the construction works generally commence in April when Japanese fiscal year starts, and works begin in May.

Even with the national subsidies, securing sufficient budget for retrofit and reconstruction projects has been hard for local governments. Most have been faced with many school facilities needing retrofit, and some facilities—constructed before the revision of the Building Standards Law in 1981—needing complete reconstruction. Some prefectural governments (mainly in areas of high earthquake risk) have subsidies available for reinforcing public facilities, including schools. Some have raised the corporate income tax in order to allocate budget for program implementation, while others have relied on interest-free loans. Municipal governments have also established special funds for project implementation, and several municipal governments have used PFIs.

Throughout the implementation process, steering committees need to reach consensus with schools and communities. In municipalities that have experienced powerful or frequent earthquakes, communities understand the need for and support school retrofitting, and consensus is easily reached. Achieving consensus is more difficult in municipalities that have experienced fewer earthquakes. Steering committees cannot simply force project implementation in the absence of the community's consensus. Thus some municipalities must decide on the acceptable contents and timing of construction works in light of community opinion or requests, and under these circumstances the work can take longer than usual.

Remaining Challenges

By the end of FY 2015, the Program for Earthquake-Resistant School Buildings had succeeded in making more than 95 percent of public elementary and junior high schools earthquake-resistant. A number of challenges in making schools safer remain, however. These include (1) making nonstructural elements of school buildings earthquake-resistant, (2) making schools safer from multi-hazards, (3) improving the functionality of schools as evacuation centers, (4) addressing aging of school buildings, (5) addressing the impacts of school consolidation, and (6) promoting seismic retrofitting in private schools.

Lessons learned

Japan's achievements under the Program for Earthquake-Resistant School Buildings offer lessons for developing countries seeking to improve the seismic safety of their schools:

1. **Building on experiences from previous disaster events** can provide momentum to accelerate school retrofitting.
2. **Information disclosure** is the key to raising public awareness and encouraging program implementation.

3. The **roles and functions of schools** in disaster risk management must be clear to determine the retrofitting and improvements necessary for school facilities.
4. **Data** needs to underpin the design and the promotion of a seismic retrofitting program.
5. **Comprehensive and flexible program development** with clear priorities and targets is important.
6. The advancement of **engineering research** should serve as a basis of developing a school retrofitting program.
7. **Proactive support by the national government**, strong initiative by program implementers and clearly defined role and function of schools within disaster management context are critical to school facility retrofitting and improvements needed.
8. **Combining** seismic retrofitting **with other facility improvement** is cost-efficient.

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Making Schools Resilient at Scale: the Case of Japan

Chapter 1
Context

This chapter describes the broad context for Japan's nation-wide Program for Earthquake-Resistant School Buildings, including the stakeholders responsible for school safety in Japan and the development and application of seismic standards over time.

1.1 Roles and Responsibilities for School Infastructure

The local government authorities who establish, fund, and oversee Japanese schools are responsible for the safety of school buildings. In Japan, municipalities (cities, towns, and villages) are the basic level of local government and prefectures are the regional level. Municipalities establish schools for nine years of compulsory education (six years of elementary school education and three years of junior high school education) within the appropriate distance from students' houses (see table 1.1). Prefectures establish senior high schools and prefectural universities.

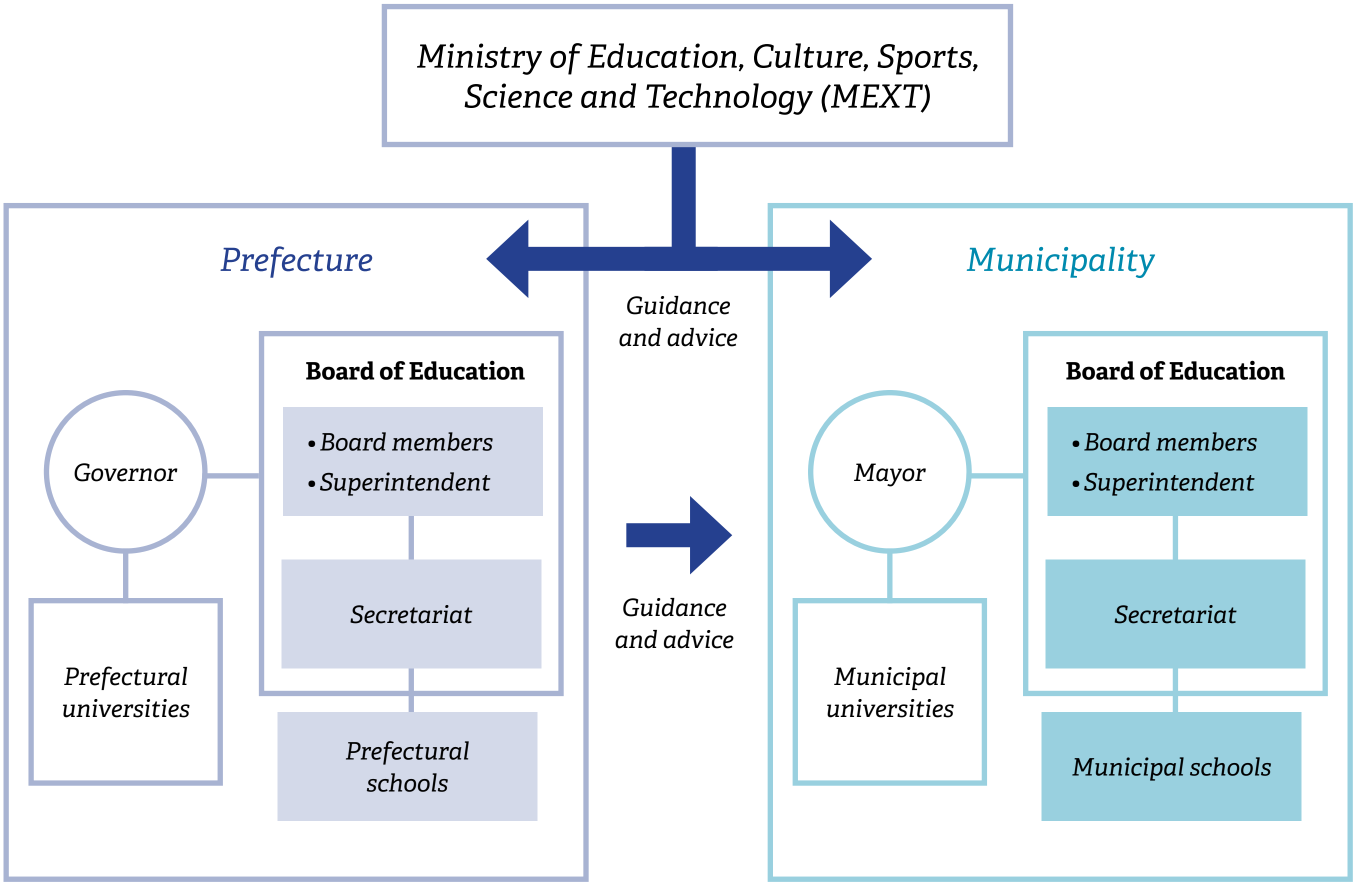
The general rule is that responsible authorities bear the expenses of their own schools, i.e., municipal governments finance elementary and junior high schools and prefectural governments finance high schools and universities. Nonetheless, the national government provides some support to local governments. In public elementary and junior high schools, major expenditures—including teacher salaries, school construction, and seismic retrofitting of school buildings—are jointly financed by the national and local governments; see table 1.2 for details.

Municipalities establish a board of education (BOE) to handle education administration. The BOE, along with the mayor and the municipal assembly, decide on school facility improvement such as retrofitting. A similar institutional mechanism exists in prefectures, formed by the governor, the prefectural BOE, and the prefectural assembly.

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) also plays a role in education administration. It develops the basic educational framework, sets standards, and offers local governments financial and technical support in achieving the targets set by MEXT. Prefectures are expected to develop standards within the prefecture, to take responsibility for tasks that need to be carried out beyond the municipalities, and to provide technical and sometimes financial support to municipalities (MEXT 1998). [1] Although the municipalities have autonomy, MEXT exerts some control over the prefectures and municipalities through its technical and financial support; the prefectures also exert some control over the municipalities in the same way (see figure 1.1).

In light of these arrangements, municipal governments have the primary responsibility of making school facilities safe, from both a managerial and a financial viewpoint, but they rely on standardized guidance and financial subsidies from MEXT and prefectural governments.

1 MEXT, 1998, http://www.mext.go.jp/b_menu/shingi/old_chukyo/old_chukyo_index/toushin/1309671.htm.



Source: Based on MEXT. "About Board of Education System"
http://www.mext.go.jp/a_menu/chihou/05071301.htm (in Japanese).
http://www.mext.go.jp/en/about/organization/title02/detail02/sdetail02/1375114.htm

FIGURE 1.1

Relationship between MEXT, local governments, and boards of education

Table 1.1 lists the number of elementary and junior high schools by the responsible local authority. It shows that the majority of these schools are under the jurisdiction of municipal governments.

Table 1.1: Elementary and junior high schools by establishing authority

Level of education	Total number	National number (share of total)	Municipal number (share of total)	Private number (share of total)
Elementary school	20,601	72 (0.3%)	20,302 (98.5%)	227 (1.1%)
Junior high school	10,484	73 (0.7%)	9,637 (91.9%)	774 (7.4%)

Source: MEXT 2015b.

Table 1.2 shows the sharing of major educational expenses among various levels of government.

Table 1.2: Sharing of major expenditures for schools by level of government

Item	National government share	Prefectural government share	Municipal government share
Textbooks	All	None	None
Salaries of teachers and staffs	1/3	2/3	None
Facilities			
New construction and expansion[a]	1/2	None	1/2
Reconstruction of hazardous buildings[b]	1/3	None	2/3
Seismic retrofitting[c]	1/3	None	2/3
Building maintenance	None	None	1

Source: Based on MEXT "About Educational Administration and Financing in Japan"
http://www.kantei.go.jp/jp/singi/kyouikusaisei/bunka/dai3/dail/siryou4.pdf,
and MEXT "About National Subsidies" http://www.mext.go.jp/a_menu/shotou/zyosei/zitumu.htm

a. The large national subsidy for new construction recognizes that municipalities are obliged to build sufficient schools where need exists, and that new construction is costly.

b. There are two types of the reconstruction: one for structurally hazardous buildings and one for educationally inadequate buildings.

c. Seismic retrofitting is necessary to ensure seismic capacity

1.2 Regulatory Environment for Earthquake Resistant Construction

In Japan, building regulations, seismic standards for buildings, and standards for seismic diagnosis—that is, evaluation of the seismic capacity of buildings—have continued to evolve in response to needs and new knowledge. That evolution is described below.

1.2.1 Development of building standards and related regulations

Seismic design was first included in building standards in Japan in 1924, after the Great Kanto Earthquake of 1923. Since then, building standards have been revised after every major earthquake. The latest major revision of building standards took place in 1981 and incorporated a new seismic design method. Accordingly, buildings that are built after 1981 are deemed earthquake-resistant, but those built before 1981 need to be evaluated for their seismic capacity based on the 1981 standards.[2] Even with the new seismic design standards, however, it is not possible to prevent earthquakes from damaging buildings. The standards aim at protecting human lives by preventing building damages that prove fatal.

Japan's early laws on building and urban planning—the Urban Building Law and the City Planning Act, both passed in 1919 as Japan grew more urbanized—did not include seismic provisions, though the Urban Building Law did specify an allowable stress threshold for each structural material. After the Great Kanto Earthquake, a set of structural provisions designed to strengthen buildings against earthquakes was added to the Urban Building Law. In 1950, the Building Standards Law replaced the Urban Building Law (Ohashi 1993), and provisions for various aspects of structural design were adopted to reinforce structural safety standards. The standard value of seismic coefficient was raised from 0.1 to 0.2, and the allowable stresses for structural materials were doubled. The essential requirements for seismic design remained the same, however.

A turning point for seismic provisions occurred following the 1968 Tokachi Offshore Earthquake, which caused significant damage to modern reinforced concrete (RC) buildings designed in accordance with building regulations (Aoyama 1981). The Building Standards Law was revised in 1971 to incorporate ultimate strength design in shear of RC buildings and to establish a reviewing procedure for the seismic safety of existing buildings.

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been the lead agency in promoting safety of infrastructure and buildings and seismic-resistant design from an engineering perspective. Its predecessor, the Ministry of Construction, established the Building Research Institute in 1942, and in the 1970s it financed the Project for Development of a New Seismic-Resistant Design Method (see box 1.1), which drew on advances in computing technology (and the resulting accumulation of strong ground motion records since the 1960s).

2 Buildings that meet the building standards are considered safe not only against earthquakes but also strong winds and snowfalls.

The new seismic design method that grew out of this project was proposed in 1979, and in 1981—three years after the Miyagi Offshore Earthquake cut off lifelines and paralyzed social and economic activities in Sendai—it was adopted in an amendment to the Buildings Standard Law. The old standard required buildings to minimize earthquake damages to minor ones in smaller and more frequent earthquakes. The new standard additionally required buildings not to collapse and to secure safety of the people inside in rare and severe earthquakes, even if buildings may become deformed and not repairable. In responding to the two requirements, both strength and ductility indicators are considered in the new seismic design, taking into the consideration of the ultimate lateral load-resisting capacity in two stages.

The 1995 Great Hanshin-Awaji Earthquake and subsequent fires highlighted the vulnerability of buildings designed prior to the 1981 revision. It led to passage of the 1995 Act on Promotion of the Earthquake-proof Retrofit of Buildings (Okada et al. 2000), which has played a key role in the nationwide campaign for the seismic diagnosis and retrofit program targeting buildings built before 1981. The Great Hanshin-Awaji Earthquake also showed the need for a new generation of seismic design (BRI 1996), and in 1998 a revised Building Standards Law introduced a performance-based design procedure to the existing prescriptive framework. New technical specifications were issued in 2000, including the definition of the performance objective: life safety and damage limitation of a building at two corresponding levels of earthquake motion (Midorikawa et al. 2003).

The Building Standards Law specifies design loadings and allowable stresses for each material along with minimum requirements for the detailing of members. Further details of structural design are specified in design standards issued by the Architectural Institute of Japan (AIJ) and "Commentary on the Structural Calculation based on the Revised Enforcement Order, Building Standards Law, (1981)" by MLIT and the Japan Conference of Building Administration. Such design standards, prepared separately for each structural type and material, have been revised frequently to adopt new technical knowledge and novel materials.

To address possible falsification of building records, the Building Standards Law added a performance code, a construction confirmation system, inspections of private enterprises, and an interim inspection system in 1998. To address falsification of structural calculation documents—a problem uncovered in 2005 that affected dozens of buildings—Japan imposed stricter regulations on the review process for plans of large-scale buildings and required a constructional design first-class registered architect to participate in the design of all larger buildings.

In Japan's most recent earthquake disaster, the 2011 Great East Japan Earthquake, most damage was due to the tsunami, although there was some shaking-induced damage to nonstructural elements, including falling ceiling materials (CDMC 2011). In 2013, the Building Standards Law Enforcement Order was revised to include seismic considerations on design and construction of nonstructural components. Also in 2013, Act on Promotion of the Earthquake-proof Retrofit of Buildings was revised to obligate owners of certain buildings—including large-scale buildings such as hotels and buildings built alongside designated major roads that serve as access roads for emergency service vehicles—to undertake earthquake-resistant building inspections (Cabinet Office 2015a).

BOX 1.1: DEVELOPMENT AND ADOPTION OF A NEW SEISMIC DESIGN METHOD

Starting in 1972, the Ministry of Construction (the precursor of MLIT) launched a five-year national research project for establishing a new seismic design method in Japan. This project was driven by advances in earthquake response analysis technology and the damage caused by recent earthquakes, including the 1968 Tokachi Offshore Earthquake. The Building Research Institute and the Public Works Research Institute assembled a project team of researchers from the private sector and universities, and in 1977, the team proposed a new seismic-resistant design method popularly called “Shin-Taishin.” The new seismic design method was adopted more quickly than anticipated: after the 1978 Miyagi Offshore Earthquake (magnitude of 7.4) killed 28 people, the new method was reviewed and evaluated as a practical design method for approximately three years. The Building Standards Law was revised in 1981, and the new seismic design method has been used since 1981.

Approximately 10 years elapsed between the start of the national research project in 1972 and the enforcement of the new Building Standard Law in 1981.

1.2.2 Development of standards for the seismic diagnosis of buildings

This section briefly describes the development of standards for seismic diagnosis and guidelines for seismic retrofit.

The Ministry of Construction (the precursor of MLIT) commissioned the precursor of the Japan Building Disaster Prevention Association (JBDPA) to develop standards for seismic evaluation and guidelines for seismic retrofit of existing buildings. Guidelines for existing RC buildings were issued in 1977, followed by similar standards and guidelines for steel structures (1979), wood structures (1979), and steel-reinforced concrete structures (1986).

The guidelines were piloted in Shizuoka Prefecture to minimize the damage of a possible Tokai earthquake (forecast in 1976), and by 1990 more than 4,000 public buildings had been evaluated and about 400 public buildings had been retrofitted. The standards and guidelines were revised based on actual practice, and they have been periodically revised to accommodate the revisions of building standards.

The standards and guidelines were widely promoted and disseminated after the pilot. This was done partly in response to the 1995 Act on Promotion of the Earthquake-proof Retrofit of Buildings, which obliged local government authorities responsible for schools to make efforts to conduct seismic evaluation and retrofit based on the experience of the Great Hanshin-Awaji Earthquake. It was also partly in response to the 2008 amendment of the Act on Special Measures for Earthquake Disaster Countermeasures, which obliged the government authorities responsible for public schools to conduct seismic diagnosis and disclose schools’ seismic capacity to the public.

Table 1.3 summarizes the evolution of regulations with major impetuses.

Table 1.3: Evolution of seismic regulation and technology in response to events

Year of change	Precipitating event	Change in regulations and technology
1924	1923 Great Kanto Earthquake caused widespread damage, leaving few buildings habitable.	*Revision of the Urban Building Law, 1924* • First enforcement of seismic design standard in Japan; structural provisions include a seismic coefficient of 0.1, added to the Urban Building Law of 1919.
1950	After WWII, concerns were raised about poor building quality and threat of urban fires.	*Introduction of the Building Standards Law to replace Urban Building Law (Law No. 201), 1950* • Includes more elaborate provisions for structural design to improve structural safety standards. • Raises standard value of seismic coefficient to 0.2, but does not change essential seismic design requirements, as comparable increase in allowable stresses for various materials accompanies increase in seismic loading.
1971	1968 Tokachi Offshore Earthquake caused significant damage to modern buildings designed in accordance with building regulations.	*Revision of the Building Standards Law, 1971* • Incorporates ultimate strength design in shear of reinforced concrete, including a specification on maximum spacing of hoops of RC columns • Establishes review procedure for existing buildings for seismic safety *Development of standard for seismic evaluation 1977* • Provides standard for seismic evaluation of existing RC buildings • Provides guidelines for seismic retrofit of existing RC buildings
1981	1978 Miyagi Offshore Earthquake severely damaged Sendai and highlighted the complicated nature of urban disasters.	*Revision of the Building Standards Law, 1981* • New Earthquake-proof Standards include two-phase design for safety against severe ground shaking; also verify the ultimate lateral load resistance of designed structure considering deformation capacity of members

Year of change	Precipitating event	Change in regulations and technology
1995	1995 Great Hanshin-Awaji Earthquake highlighted the vulnerability of buildings designed before 1981.	*Introduction of the Act on Promotion of the Earthquake-proof Retrofit of Buildings, 1995* • Includes a prescribed measure for seismic retrofit and guidelines for seismic diagnosis and retrofit. • Revised in 2006 in order to promote seismic retrofit of existing buildings designed to the pre-1981 standards and to increase the seismic retrofitting ratio of housing and specified buildings (schools, nursing homes for the elderly, etc.) from 75% to 90% within 10 years • Establishes special committee on seismic retrofit evaluation for existing buildings under JBDPA
2000	1995 Great Hanshin-Awaji Earthquake resulted in extensive destruction of infrastructure and buildings.	*Introduction of alternative seismic design method, "Response and Limit Deformation," in the Building Standards Law, 2000* • Introduces performance-based design procedure to existing prescriptive framework and defines performance objective: life safety and damage limitation of a building at two corresponding levels of earthquake motion
1998; 1999; 2000; 2001	Suspicions were raised about the quality of housing.	*Revision of the Building Standards Law, 1998* • Introduces performance code, opens construction confirmation and inspections to private enterprise, and introduces interim inspection systems. *Development of laws, standards, and guidelines to avoid defective residence problem* • Law Concerning the Promotion of Quality Guarantee of Housing, 1999 • Residential performance display standards for newly built residences, 2000 • Evaluation system based on the guidelines for earthquake resistance evaluation formulated by MLIT, 2001

Year of change	Precipitating event	Change in regulations and technology
2007, 2009	Falsification of structural calculation documents ("Aneha Scandal") was discovered in 2005.	*Implementation of stricter regulations on the review process for plans of large-scale buildings, 2007* *Revision of the Licensed Architect Act, 2009* • Requires larger buildings to be structurally designed by a constructional design first-class registered architect
2013	Great East Japan Earthquake in 2011 was tremendously destructive. Most of damage was due to the tsunami, but some damage occurred to nonstructural elements (including falling ceiling materials).	*Revisions of the Law Concerning the Promotion of Seismic Retrofit of Buildings, 2013* • Obligates owners of large-scale buildings (hotels, institutions) and owners of buildings alongside designated major roads to undertake earthquake-resistant building inspections (the latter ensures access for emergency vehicles) • Relaxes certification criteria on seismic retrofit plan and resolution requirements for condominium ownership (to extend application) • Introduces seismic performance display system *Revisions of the Building Standards Law Enforcement Order, 2013* • Requires nonstructural components such as large-size suspended ceiling systems to be designed and constructed with detailing in accordance with new technical regulations

Chapter 2
The Program for Earthquake-Resistant School Buildings

This chapter offers an overview of Japanese efforts to make school buildings earthquake-resistant. It explains the background to the Program for Earthquake-Resistant School Buildings, then describes the program's development, priorities, and achievements as well as key factors that drove and facilitated its promotion.

2.1 Overview

Making schools earthquake-resistant has been a long-time effort of both the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and local governments. For MEXT, promoting earthquake-resistant school buildings has not been a time-limited initiative but rather an ongoing endeavor, one whose priorities continue to evolve based on feedback from earthquake experience and technical advances. The discussion in this chapter focuses mainly on the period between FY2003 and FY2015,[3] a time of major achievements in making schools earthquake-resistant: the acceleration of school retrofitting started in FY2003, when MEXT issued its comprehensive guideline and the Program for Earthquake-Resistant School Buildings took it's speed, while FY2015 was the target year for completing retrofitting of public elementary and junior high schools.

3 Japan's fiscal year in starts in April and ends in March, so FY2015 runs from April 2015 to March 2016.

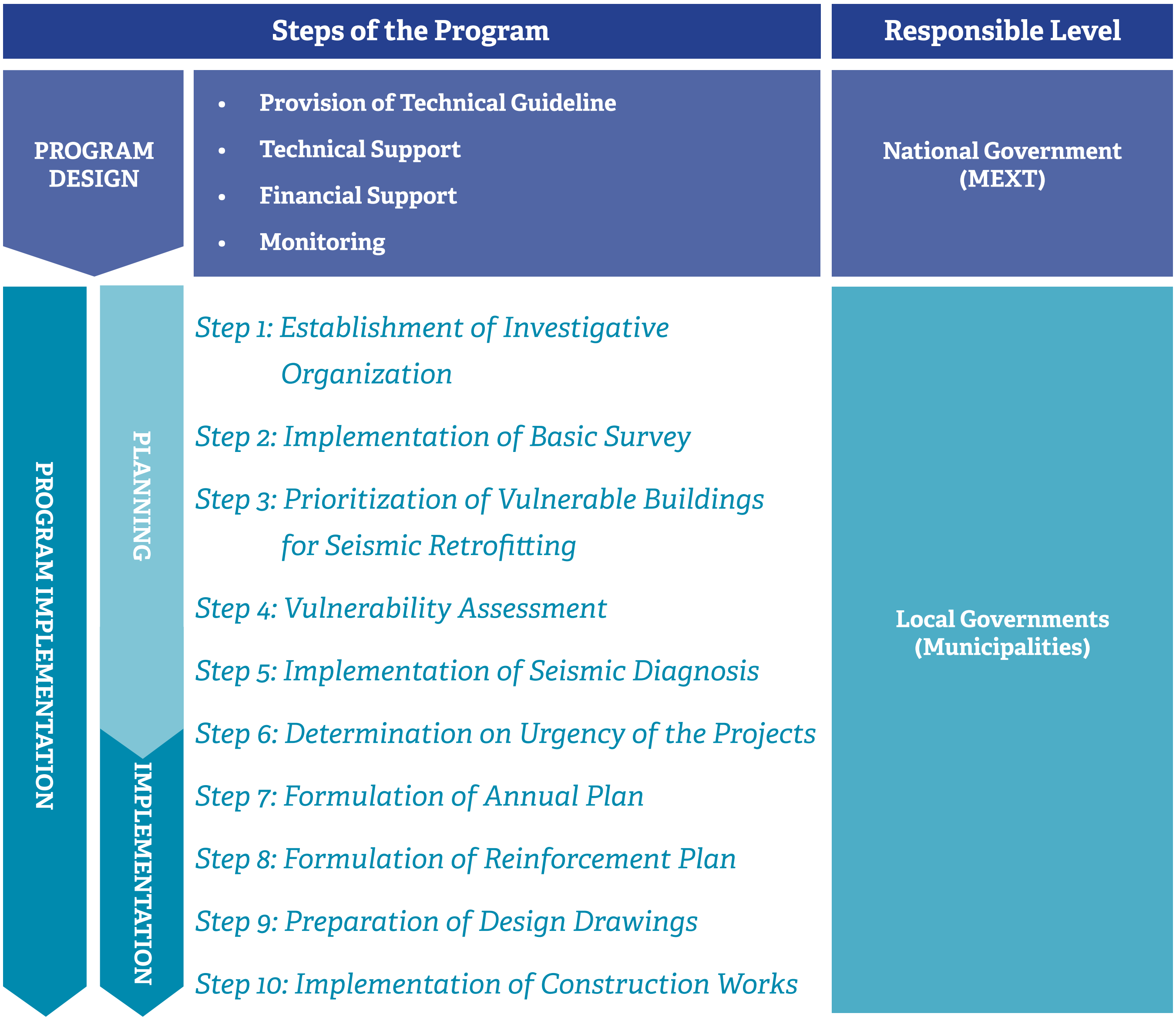


FIGURE 2.1

Steps of the program and responsible government level

Japan's efforts to make schools earthquake-resistant combine policies developed by the national government, mainly MEXT, and implementation by local governments. Under the Program for Earthquake-Resistant School Buildings, MEXT sets policies, arranges financial schemes, and provides technical guidance in the phase of program design, while municipalities develop plans for implementing school retrofitting and realize them by taking necessary actions with the support of prefectural governments and the national government (see figure 2.1).

The program targets existing school buildings and seeks to ensure that they are earthquake-resistant. School buildings constructed under the 1981 building standards that incorporated the New Earthquake-proof Standards are deemed to be earthquake-resistant[4], while those built before 1981 must be evaluated and then retrofitted if the seismic capacity does not meet the standards (see box 2.1).

BOX 2.1:
WHY MANY SCHOOLS WERE DEEMED UNSAFE AT THE BEGINNING OF THE PROGRAM

In the 1970s, when Japan experienced a rapid increase in the number of schoolchildren, many elementary schools and junior high schools were built to the standards of the time. Building standards were revised in 1981 to incorporate the New Earthquake-proof Standards. The Great Hanshin-Awaji Earthquake in 1995 revealed that many buildings built with the pre-1981 standards lacked sufficient seismic capacity. In order to ensure their safety, these buildings underwent seismic diagnosis, and where seismic capacity was found to be insufficient, they were retrofitted or reconstructed.

Local governments did not move quickly to diagnose and retrofit schools, due in part to the high cost of seismic diagnosis (usually more than a few million yen a year for one school building). To address these delays, in 2003 MEXT issued a clear guideline to prioritize and plan the seismic retrofit. School buildings built after 1981 using the latest building standards were considered earthquake-resistant and were excluded from the targeted seismic diagnosis and retrofitting under the program.

2.2 The Start of the Program

The national government's initiative for making schools earthquake-resistant was first introduced in 1978. Legally mandated national subsidies were prepared for reconstruction and seismic retrofitting of public elementary and junior high schools in the Tokai and southern Kanto regions, where earthquakes were deemed likely. [5]

But the 1995 Great Hanshin-Awaji Earthquake affected a different part of the country, one with comparatively low levels of earthquake preparedness. This event, which caused serious damage to school facilities (it damaged 3,883 schools in total), became a fresh reminder that earthquakes could happen anywhere and at any time. In response, MEXT commissioned the Architectural Institute of Japan (AIJ) to survey the seismic capacity of education infrastructure (AIJ 1997). The survey showed that damage was concentrated in buildings built before 1981, and that the intensity of damage depended on the seismic capacity of individual buildings. These results confirmed the necessity of school retrofitting, and in 1995 additional subsidies for seismic retrofitting, which had been limited to the Tokai area, were extended to the entire nation. MEXT issued an announcement in the following year urging local government authorities to enhance schools' earthquake resistance through seismic diagnosis and seismic retrofitting using the results of the AIJ survey. Such efforts were closely aligned with the country's revised Basic Disaster Management Plan.

In February 2002, a survey by the Fire and Disaster Management Agency (FDMA) found inadequate earthquake resistance in school facilities: only 31 percent of school buildings that were constructed with pre-1981 standards had completed the seismic diagnosis, and only 46 percent had satisfied the required seismic capacity as of April 2002. These figures raised an alarm at the slow pace of local governments' efforts to make schools seismic-resistant. Since the FDMA survey covered only schools that were designated as evacuation centers, MEXT

4 This applies only to reinforced concrete school buildings, which means the majority of school buildings.

5 The additional national subsidy was prescribed in the Act on Special Financial Measures for Urgent Earthquake Countermeasure Improvement Projects in Areas for Intensified Measures (1980).

followed with a survey in May 2002 to assess the status of all public elementary and junior high schools in the nation. The survey showed a more serious result: 31 percent of the 88,000 school buildings built before 1981 had completed the seismic diagnosis, and only 44.5 percent of all existing school buildings and facilities had been confirmed as earthquake-resistant.

In need of comprehensive and practical guidelines that would help local governments to promote seismic-resistant school buildings in a timely manner, in October 2002 MEXT convened an expert group to survey and study promotion of earthquake-resistant school facilities. Academic experts on building structures, building planning, and seismic research, as well as architects and representatives of local governments, examined issues regarding promotion of seismic-resistant school buildings and the methodology for planning reconstruction and seismic retrofitting. The emphasis for this research was on developing concrete measures for local governments.

MEXT used the group's final report (MEXT 2003a), which was published in April 2003, to develop the "Guidelines for Promotion of Earthquake-Resistance School Building" (MEXT 2003b). Issued in July 2003, this work describes the basic principles for making schools earthquake-resistant, methods for planning for earthquake-resistance promotion, and methods for determining the urgency of earthquake-resistance projects. The guidelines marked the beginning of the Program for Earthquake-Resistant School Buildings and include the program's six principles:

1. Seismic diagnosis and vulnerability assessment should prioritize schools with the poorest seismic capacity for earthquake-resistant activities.
2. Seismic diagnosis should be prompt and should use the standards appropriate for the construction type.
3. Municipal governments should disclose results of the seismic diagnosis and progress under the program to stakeholders, including teachers, parents, and communities.
4. Nonstructural elements of school facilities should be inspected and necessary measures taken to ensure their earthquake resistance.
5. General improvements in the quality of school facilities should be carried out at the same time as earthquake-resistance improvements.
6. The earthquake-resistance promotion plan should be formulated promptly by local governments.

In addition to building on the expert group's report, the MEXT guidelines also incorporated findings from several studies conducted between 1995 and 2002; see figure 2.2 for a summary.

FIGURE 2.2
Background studies for the Program for Earthquake-Resistant School Buildings

Study of seismic capacity of school facilities (1995–2002)

Focus: Measures to ensure earthquake-resistance of individual buildings

Examination of technical considerations regarding the seismic capacity of educational facilities based on the survey of damages caused by the Great Hanshin-Awaji Earthquake.

Consideration in planning for earthquake-resistance and design of new and existing buildings	• Publication of "Promotion of Improving Seismic Capacity of Educational Facilities" (1995, 1996) • Publication of "Promotion of Improving Seismic Capacity of Educational Facilities" (1999) (integrating the above two announcements)
Formulation of standards of seismic diagnosis for gymnasiums	Formulation of standards of seismic diagnosis for gymnasiums (1996)
Provision for seismic diagnosis and retrofitting of precast concrete (roof of large structures)	Publication of the report "Study on Seismic Capacity of Educational Facilities" (1997)
Provision for diagnosis and retrofitting methods for nonstructural elements	Publication of "Ensuring Seismic Capacity of Nonstructural Elements of School Facilities" (2002)
Provision for methods of seismic retrofit of school facilities with functional improvement	Publication of "Promotion of Seismic Retrofit of School Facilities"—ensuring seismic capacity of nonstructural elements of school facilities (2002)

Study on promoting earthquake-resistant school facilities (FY 2002)

Focus: Measures to ensure earthquake-resistance of school facilities in the community

• Recommendation of basic principles for promoting seismic retrofit of existing school facilities • Recommendation of planning methods and principles in promoting seismic retrofit	Publication of report by group convened to survey and study promotion of earthquake-resistant school facilities (2003)

- **Dissemination of the report to municipal/prefectural governments and architects through dissemination seminars**
- **Support for development of plans for promoting earthquake-resistant school facilities by municipalities (FY 2003–FY2007)**

Source: Based on MEXT 2002.

2.3 Priorities

The priorities of the Program for Earthquake-Resistant School Buildings have evolved over time, not only in response to the country's continuing experience with earthquakes but also in response to the program's own progress.

Early on, the program focused on schools' structural seismic resistance. But when the Great Hanshin-Awaji Earthquake highlighted the risks posed by nonstructural elements, MEXT prepared guidelines for making nonstructural elements earthquake-resistant. Fifteen years later, the Great East Japan Earthquake highlighted the need for tsunami countermeasures and functional improvement of schools as evacuation centers. MEXT also took this opportunity to reexamine damage to nonstructural elements and measures to prevent damages in the future; the conclusions were summarized in a collection of case studies and guidebooks.

Another shift in priorities occurred as the majority of schools became earthquake-resistant. MEXT then started to face the impending issue of how to maintain aging school facilities. In accordance with a 2013 plan developed by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) for extending the life span of infrastructure, MEXT developed guidelines for extending buildings' life span through measures that could be carried out in conjunction with school retrofitting.

March 2016 was the target date by which all schools were to be earthquake-resistant, specifically in terms of their main structure and the suspended ceilings found in gymnasiums. But efforts to make school buildings safer will continue. Ensuring the safety of nonstructural elements, equipping more disaster-resilient facilities, and extending the life span of existing buildings are the current priorities.

Technical meetings commissioned by MEXT played a crucial role in developing both the policies and the concrete measures for earthquake resistance of schools. The meetings brought together groups of academics and practitioners who could respond to new and emerging needs related to school retrofitting and so formulate the new priorities. A list of the meeting topics and description of how the results contributed to the development of MEXT policies are included in annex 2A.

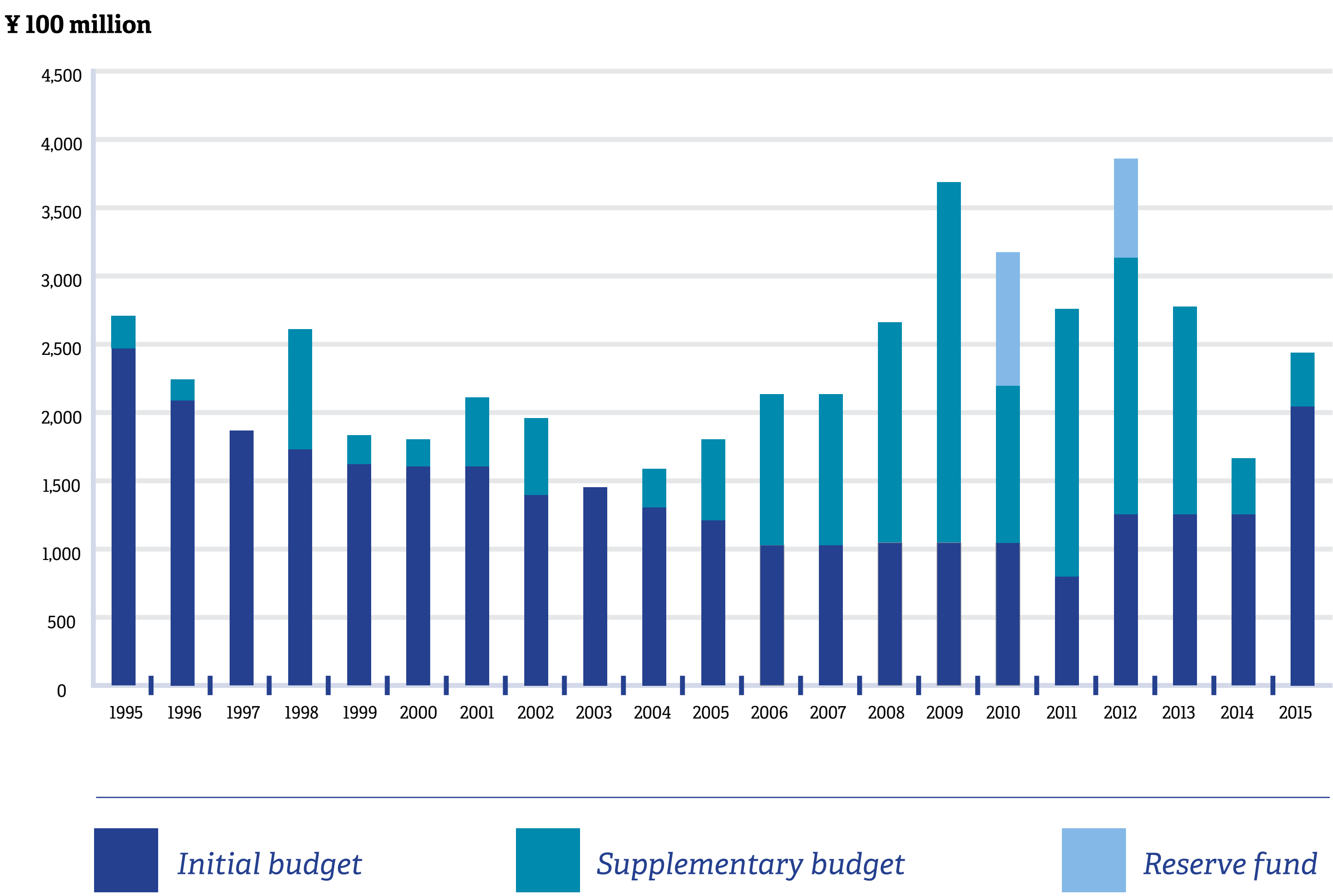
2.4 Achievements

As a result of the program, the share of earthquake-resistant public elementary and junior high schools has significantly increased. In 2002, earthquake-resistant schools accounted for 44.5 percent of the total; in April 2015 they accounted for 95.6 percent (figure 2.3). Most of the remaining percent of buildings have to be postponed due to the planned consolidation or closure of the schools. Since 2003, approximately 52,000 buildings have been confirmed earthquake-resistant by seismic diagnosis or seismically improved by seismic retrofitting or reconstruction. [6]

Progress under the program sped up after 2008, partly in response to the revision of the Act on Special Measures for Earthquake Disaster Countermeasures. The revised act increased the national subsidy for school retrofitting and reconstruction and made local governments responsible for seismic diagnosis and disclosure of the results.

6 The decrese in remaining buildings is due to either confirmed safe by seismic diagnosis or seismic retrofitting or reconstruction.Seismic diagnosis for the majority of existing school buildings were completed by 2007. Therefore, the decrease in remaining buildings after 2007 was mostly due to seismic retrofitting or retrofitting.

In addition to these achievements in ensuring the overall structural resilience of school buildings, MEXT has also made considerable progress in ensuring the safety of nonstructural elements. As early as 2002 it developed a relevant guideline, and in 2008 it began preparing the national subsidy. For a few years, progress in retrofitting of nonstructural elements was slow, mostly due to the limited budget at the local government level. But after the Great East Japan Earthquake, MEXT prioritized the suspended ceilings (nonstructural) in gymnasiums, which can cause fatal injuries if they fall. Since then, there has been significant progress in removing suspended ceilings, retrofitting ceilings, and installing ceiling safety nets. As of April 2015, 85.5 percent of school ceilings were considered safe (including gymnasiums without a suspended ceiling), and 93 percent of schools had conducted the inspection for major nonstructural elements.



Source: MEXT 2015c.
Note: The data are as of April for each year.

FIGURE 2.3
Share of public elementary and junior high schools whose main structures are earthquake-resistant

2.5 Drivers of Success

To understand the program's evolution and achievements, it is important to recognize certain key factors that drove or facilitated its development and promotion. These include (1) the experience of earthquakes; (2) the accumulation of engineering research and practices; (3) the availability of data, specifically data on schools, on damages caused by past earthquakes, and on hazard risks; and (4) the political will to carry out the program.

2.5.1 Occurance of Large Earthquakes

The important effect of the 1995 Great Hanshin-Awaji Earthquake—in particular what it revealed about the earthquake resistance of pre-1981 buildings, and how it led to the development of the comprehensive guidelines—has already been described (section 2.2). But at least three other earthquakes also exercised significant influence on the program. The 2004 Chuetsu Earthquake increased the nascent program's momentum. The May 2008 Sichuan (China) Earthquake, which caused the collapse of 6,898 school buildings (Minemura 2008) and the deaths of 19,065 schoolchildren (Author unknown. 2008), drove Japanese politicians and MEXT officials to make the program stronger: less than a year after the Sichuan Earthquake, the revised Act on Special Measures for Earthquake Disaster Countermeasures was passed, providing more money for school retrofitting and reconstruction and increasing the role of local governments. Finally, the experience of the 2011 Great East Japan Earthquake induced the program to give higher priority to nonstructural elements, including certain ceilings and exterior materials. This earthquake also highlighted the need for tsunami countermeasures and functional improvement of schools as evacuation centers.

2.5.2 Prior Engineering Experience and Research

Of particular relevance to the program is the development in 1949 of a prototype school building of reinforced concrete (RC). Commissioned by the Ministry of Education, Science and Culture (the precursor of MEXT), the AIJ developed four unit plans with complete drawings using a model school in Tokyo; this marked the beginning of architectural development of school buildings. A prototype steel-frame structure was developed in 1954, but the RC prototype was more widely accepted because it was considered more earthquake-resistant from the engineering point of view, and because it was easily replicable without additional structural calculation and plan drawing. This prototype was employed in many schools built during the 1970s and 1980s. Its use has made retrofitting of those schools fairly standardized and hence efficient.

The development of standards for seismic evaluation and guidelines for seismic retrofit of existing buildings, which grew out of a pilot program in Shizuoka Prefecture[7], were also highly relevant to the program. In 1976, in response to the prediction of a possible Tokai earthquake centered in Suruga Bay, the governor of Shizuoka Prefecture asked experts at the University of Tokyo for technical support in making buildings earthquake-resistant. The prefecture completed seismic retrofitting for all prefectural buildings in 2006, after more than 30 years of work. In the process, engineering research and practices were developed that would serve the needs of the program:

- An evaluation standard for seismic capacity for RC structures was developed and applied (1977).
- The Special Committee on Seismic Evaluation of Public Buildings was established (1978). It served as the model for the later Committee on Seismic Assessment Judgment. [8]
- Methods were developed for seismic retrofitting for RC structures, such as use of steel-frame

7 This section is based on Shizuoka Architectural Firms Association (2012).

8 Results of seismic evaluation needs to be validated by this committee. See Step 5 in 3.1.1 for details.

braces and steel walls (1982–).

- The method for seismic evaluation of steel-framed gymnasiums was developed (1990–).
- A certification system was established in which experts conducted quick post-earthquake inspections of damaged buildings (1991). Those experts played an active role after the 1995 Great Hanshin-Awaji Earthquake.
- A method was developed for temporary seismic retrofitting of buildings requiring reconstruction (2001).

These developments in seismic engineering and implementation all grew out of the Shizuoka Prefecture initiative, which benefited from extensive research by the University of Tokyo and Japan Building Disaster Prevention Association, and cooperation with the Shizuoka Architectural Firms Associations. These standards, methods, and systems have been fully utilized throughout Japan to promote seismic retrofitting efforts under the Program for Earthquake-Resistant School Buildings.

2.5.3 Availability of Data

Data were crucial to the design and promotion of the program. Three types of data have been particularly important: school data, data on damages caused by past earthquakes, and data on hazard risks.

School data. As described earlier, the Program for Earthquake-Resistant School Buildings was begun because of alarming data on schools. The 2002 FDMA survey, which indicated poor seismic capacity of public school buildings and weak effort to remedy it, drove MEXT to conduct a wider survey, which confirmed the FDMA findings. These concerning data triggered MEXT's development of the comprehensive guideline for making schools earthquake-resistant.

Ongoing annual school surveys conducted by MEXT—the School Basic Survey and Public School Facilities Survey—continue to play an important role in the program by providing the basic school infrastructure inventory. The former survey provides data on the number of classrooms and students, and information on school facilities for all levels and types of schools; and the latter provides quantitative data related to public school facilities, such as building area and condition. (More detail on these two surveys is in annex 2B.)

To gain other needed information for the program, MEXT has conducted an additional survey, the Status of Seismic Resistance of Public School Facilities, annually since 2002. The survey covers all governing authorities (municipalities and prefectures) for kindergartens, elementary schools, junior high schools, senior high schools, secondary schools, and special-needs schools. It collects data on the seismic resistance of school structures (both wood and nonwood) as well as suspended ceilings of gymnasiums and other nonstructural elements of school buildings.

All the collected data are used to monitor the progress of the program and to determine additional support or measures required by MEXT. Data are also disclosed to the public to indicate program results and progress. Municipalities and prefectures that have been slow in promoting the program are named in press releases, and prefectures and municipalities are ranked by the percentage of earthquake-resistant school buildings. This tactic has proved effective in stimulating the local authorities to take prompt action.

Data on damages. Another fundamental data set used to direct policies concerns damage to buildings, specifically the kind of damage suffered by various types of buildings, the location where the damage occurred and under what circumstances, and the kind of earthquake (intensity, cycle, and length of shaking) that caused the damage. This information is collected by the earthquake damage investigation. For mega-disasters like the Great Hanshin-Awaji Earthquake and the Great East Japan Earthquake, MEXT has commissioned an expert group (AIJ) to conduct the survey. MEXT typically collects the data on damages through municipalities and prefectures as well as through a direct field survey for each earthquake. Lessons learned from these data are reported to MEXT and used to minimize the damage caused by future earthquakes.

Data on hazard risk. Data on earthquake risk, and in particular data showing where that risk is elevated, are used by the national government to prioritize necessary actions. Seismological research has identified those areas that require intensified measures to mitigate earthquake damages, namely the Tokai, southern Kanto, and Nankai regions. This information has been incorporated in laws to promote mitigation of risks—for example, through provision of additional subsidies (see box 2.2). This risk information has also raised people's awareness and led to strong support for efforts by national and local governments to make schools earthquake-resistant.

BOX 2.2: HOW LAWS REFLECT DATA ON ANTICIPATED FOCAL AREAS AND DAMAGES

Research on seismology advanced significantly during and after the 1970s. In 1976, the Seismological Society of Japan found that a large subduction zone earthquake in Suruga Bay near Shizuoka Prefecture was probable. The yet-to-come Tokai Earthquake became a large social concern, in particular to the Tokai region itself, including Shizuoka Prefecture. With the strong leadership of the prefecture's governor, intensive, ongoing efforts have been to ensure the prefecture's earthquake resilience.

In 1978, in accordance with the Act on Special Measures Concerning Countermeasures for Large-Scale Earthquakes, the Central Disaster Management Council predicted the assumed epicenter of the Tokai Earthquake, and areas requiring intensified measures to prevent earthquake disasters were designated (Cabinet Office 1978). The Act on Special Financial Measures for Urgent Earthquake Countermeasure Improvement Projects in Areas for Intensified Measures (Cabinet Office 1980) was enacted in 1980 to support anti-earthquake projects in high-risk areas, by increasing the ratio of national subsidies for seismic retrofitting of public elementary and junior high schools from one thirds to one half. Using the subsidy supported by the special financial measure, a large number of public elementary schools and junior high schools of Tokai region were retrofitted. The measure of additional subsidies were later expanded to the nationwide after the 1995 Great Hanshin-Awaji Earthquake.

As of 2015, the government had identified several regions at elevated seismic risk (Cabinet Office 2015), including the Chubu and Kinki regions. The CDMC announced the estimated human and physical damages in 2007, and it published its estimation of the damages on transportation systems, economy, and lifelines in 2008. The countermeasures against the earthquake include promotion of disaster management measures in the city areas with high concentrations of wooden houses, a damage reduction plan for the cultural heritage areas in the Kyoto and Nara areas, and security plans for the petrochemical plant complexes concentrated in Osaka and Ise Bays.

2.5.4 Political Will

The political will to make schools safe is strong in Japan. The policy has been popular among politicians, i.e., members of the Diet, for both humanitarian and economic reasons. In a culture that prioritizes human life, a policy for making schools earthquake-resistant has the noble aim of saving the lives of schoolchildren. The policy also is considered an effective investment that contributes to local economies and produces tangible results that are well-received by the public. Thus the major political parties have supported acceleration of school retrofit and helped to secure the budget for the purpose.

These efforts have largely been bipartisan. Devastating damages to school buildings and fatalities of schoolchildren caused by the Sichuan Earthquake in China caught the attention of the people in Japan to the safety of Japanese school buildings. Being aware of the fact that all Japanese schools were not yet earthquake-resistant mostly due to the financial limitations of local governments, members of the Diet voted to revise the Act on Special Measures for Earthquake Disaster Countermeasures in order to reduce the burden on local governments for school retrofitting. The increased subsidy rate was extended in 2011 for five years and again in 2016 for another five years by the efforts of members of the Diet.

Discussions held in certain Diet committees, including the Special Committee on Disaster Management, the Committee on Education and Science, and the Committee on Budget Planning, also contributed to development and promotion of the program and helped to secure the program's budget.

Chapter 3
Program Design and the Role Played by the National Government

Through the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the national government is responsible for directing and supporting local governments' implementation of school retrofitting projects. This chapter describes MEXT's provision of technical support, preparation of financial measures, and monitoring of the projects' progress. It also highlights some of the challenges MEXT has faced as the program has been carried out, and MEXT's responses.

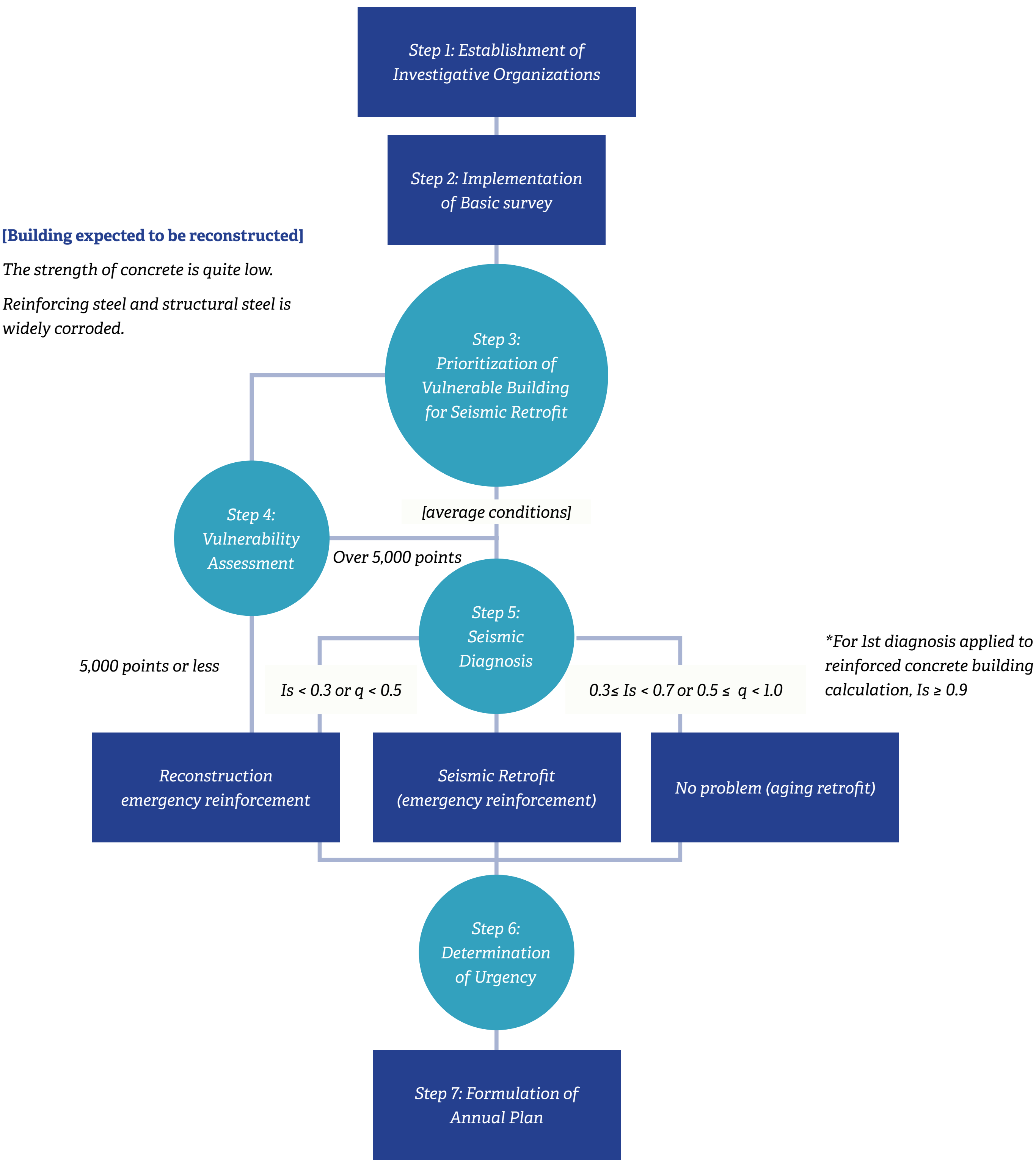
3.1 Prioritization

MEXT lays out the basic principles of school retrofitting in the first chapter of the "Guidelines for Promotion of Earthquake-resistance School Building" (MEXT 2003b); subsequent chapters suggest steps for planning school retrofitting, including methods for how to use the results of seismic diagnosis to prioritize vulnerable buildings and judge the urgency of retrofitting. The next section explains these steps.

3.1.1 Prioritization Process

The MEXT guidelines include a flow chart (figure 3.1) to guide planning for earthquake-resistant school buildings by local governments, the implementers of the program. The main purpose of the flowchart is to show how to prioritize the most hazardous buildings over others to minimize damages. The seven steps shown in the chart are explained below.

FIGURE 3.1
Flowchart for formulating a plan for earthquake-resistant school buildings



Source: Adapted from MEXT 2003b.
Note: Is = seismic index of structure; q = horizontal load-carrying capacity index.

Step 1: Establish an investigative organization. The guideline suggests the establishment of a local government steering committee that consists of the board of education and relevant departments and agencies, such as finance, construction, and disaster prevention, as well as academic experts on architectural structure, designers, and teachers and staff of schools. This approach makes it possible for stakeholders to reach a common understanding about the importance of earthquake-resistant school facilities. The guideline also recommends developing a subgroup of engineering experts within the committee to support planning.

Step 2: Implement the basic survey. The basic survey has five concerns: (1) condition of facilities, (2) confirmation of design drawings and documents, (3) collection of data and information on any active fault and subductional zone earthquake, (4) confirmation of school's designation as an evacuation center, and (5) identification of any merger or closure plan. Table 3.1 provides more detail. The information collected in the survey is utilized in the remaining steps.

Table 3.1: Focus areas and items of basic survey

Focus area	Items to be surveyed
(1) Condition of facilities	• Basic information: › Year of construction › Building area › Number of buildings • Results of the seismic diagnosis and vulnerability assessment, if any • Information on previous retrofitting activities, if any • Damages by previous natural disasters, if any
(2) Confirmation of design drawings and documents	• Availability and contents of design documents: › Design drawings and documents (design and structure) › Structural calculation sheets › Ground survey data and information • Development of floor plans and framing elevations and other necessary documents through site survey in case the original documents are unavailable • Comparison of the design drawings and documents with the actual conditions of the buildings
(3) Collection of data and information on any active fault and subductional zone earthquake	• Collection of data and information: › Location of active fault › Estimated focal region of subductional zone earthquake › Expected scale of earthquake motion › Estimated damages by the earthquake motion • Utilization of "Seismic Hazard Map in General View of the Whole Japan" and "Seismic Shaking Map for Specified Seismic Source Faults" prepared by the Headquarters for Earthquake Research Promotion
(4) Confirmation of school's designation as evacuation center	• Confirmation of whether the school facilities are designated as a disaster evacuation center in the local disaster management plan
(5) Identification of any merger or closure plan	• Identification of merger, closure, or diversion plans of schools and local governments

Source: Based on MEXT 2003b.

Step 3: Conduct survey to prioritize vulnerable building for seismic retrofitting. MEXT suggests that local governments conduct the survey to prioritize vulnerable buildings before conducting a vulnerability assessment and/or seismic diagnosis. The objective of the prioritization survey is to determine which buildings should be prioritized for the vulnerability assessment and/or seismic diagnosis. This step is particularly useful where there are many school buildings and the local government cannot simultaneously assess or diagnose them all. Where the number of school facilities is small and local governments are able to directly conduct vulnerability assessment and/or seismic diagnosis, the prioritization survey can be skipped.

The prioritization survey has been established only for reinforced concrete (RC) school buildings and structural steel-framed gymnasiums, which are the most common type of school facilities in Japan. Both types are discussed below. For other structural types—such as wooden, concrete block, and steel-reinforced concrete facilities—MEXT recommends conducting the prioritization in cooperation with experts and reference to the relevant guidelines.

The prioritization survey for RC school buildings is based on (1) basic classifications, including year of construction and number of floors; and (2) correction items, including concrete strength, degree of aging, floor plan, wall alignment, and assumed seismic intensity. See Annex 3B for a detailed description of the prioritization study.

Steps 4 and 5: Conduct vulnerability assessment (Step 4) and seismic diagnosis (Step 5) Depending on the results of the prioritization survey, either a vulnerability assessment or seismic diagnosis is conducted. When the strength of concrete is quite low or reinforcing steel and structural steel are widely corroded, and when the likelihood of reconstruction is high, a vulnerability assessment is conducted. On the other hand, when buildings are found to be in average or above average condition, seismic diagnosis is conducted without vulnerability assessment.

Vulnerability assessment determines the degree of deterioration of school buildings comprehensively, looking at the structural strength of the building, the deterioration of its strength due to aging, and impacts of locational conditions. The assessment calculates buildings' vulnerability score out of a total of 10,000. If the calculated score is 4,500 or less, the building is considered dangerous and is slated for reconstruction. Such a building is eligible for the national subsidy for reconstruction, and the results of the vulnerability assessment also serve as the evidence necessary in requesting the national subsidy. [9]

If the calculated score of the vulnerability study is over 5,000, the next step is to conduct seismic diagnosis to determine the level of seismic capacity. The same process of seismic diagnosis is carried out for buildings in average or above average condition.

The aim of seismic diagnosis is to judge the degree to which a building can withstand an earthquake from the perspective of structural dynamics, and to evaluate the safety (aseismic capacity) of the building when the building is expected to be continuously used.[10] The guidelines for the seismic diagnosis are published by the Japan Building Disaster Prevention Association (JBDPA) under the supervision of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) (see JBDPA 2001a, 2001b). The entire evaluation must be conducted by a constructional design first-class registered architect and his or her office.

9 MEXT plans to revise the procedures for vulnerability assessment by 2017 to incorporate revisions in related laws and regulations as well as advances in building engineering. Kensetsu News, April 15, 2016, https://www.kensetsunews.com/?p=64196.

10 In the context of school buildings, seismic diagnosis examines the seismic capacity of buildings that were designed under the pre-1981 building standards in light of the latest building standards.

In order to evaluate the seismic performance of the buildings based on pre-1981 building standards, the seismic index of structure (Is) and the horizontal load-carrying capacity index (q or CTUSD) resulted from the seismic diagnosis are utilized. The procedure for computing the seismic index of structure is briefly described in annex 3A. The seismic performance standards for Is and q defined by MLIT are summarized in table 3.6.

Table 3.6: Evaluation standard of seismic performance based on Is and q

Is < 0.3 or q < 0.5	The risk of collapsing from the shock of earthquake is high
0.3 ≤ Is < 0.6 or 0.5 ≤ q < 1.0	There is a risk of collapsing from the shock of earthquake
0.6 ≤ Is and 1.0 ≤ q	The risk of collapsing from the shock of earthquake is low

Source: Based on Act on Promotion of the Earthquake-proof Retrofit of Buildings (1995)
Note: Assumed seismic intensity is between VI and VII on the Japan Meteorological Agency seismic intensity scale.

When *Is* is found equal to or greater than 0.6, the building is considered safe, and the risk of collapsing from the shock of earthquake is low. When *Is* is less than 0.6, seismic retrofitting is necessary as prescribed in the Act on Promotion of the Earthquake-proof Retrofit of Buildings. Using the Japan Meteorological Agency seismic intensity scale of I to VII, with V and VI each divided into "lower" and "upper," the expected seismic capacity with the standard of 0.6 ≤ *Is* is as follows: [11]

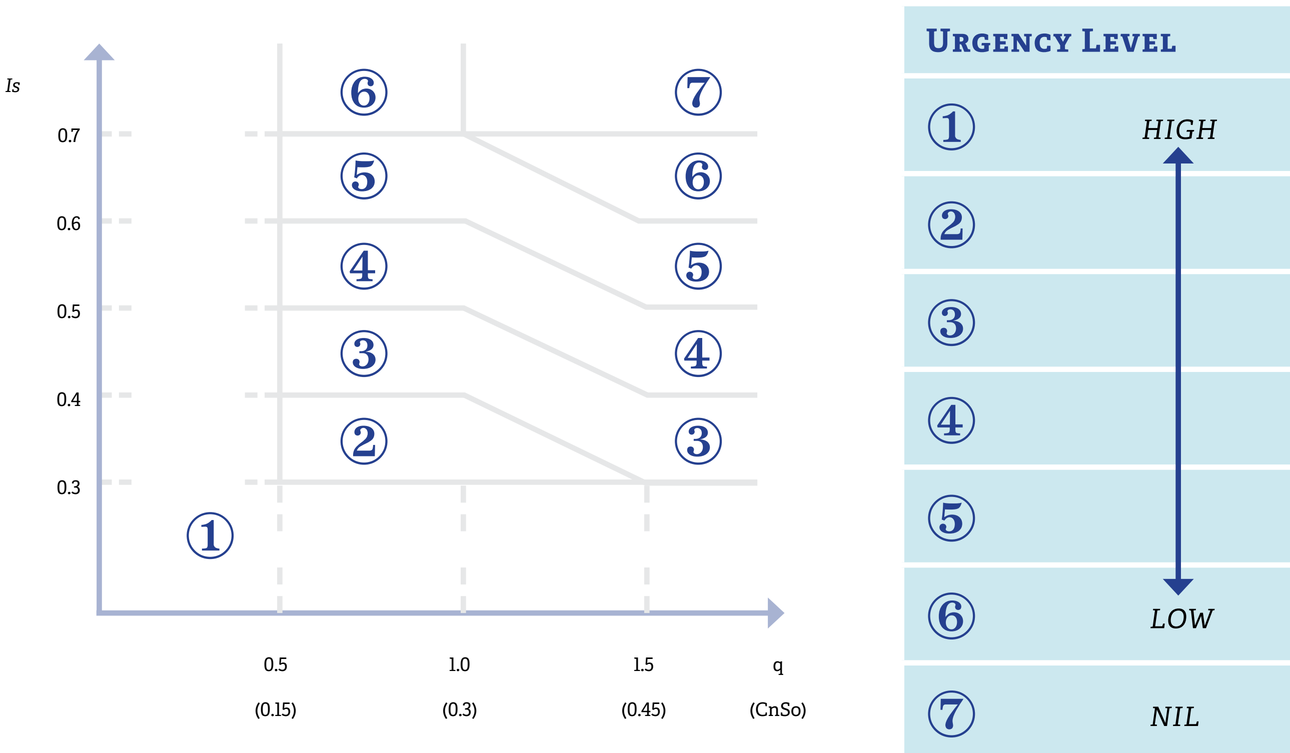
Earthquake with seismic intensity of VI (upper) and VII: Buildings may be partly damaged, but will not collapse, no threat to human life.

- Earthquake with seismic intensity of V (upper): Buildings will not be damaged.
- It should be highlighted that the standard for school buildings is set at 0.7 < *Is* and 1.0 < *q*, considering the need to ensure the safety of schoolchildren and schools' function as evacuation centers, as prescribed in the operational details defined by MEXT.

The urgency of the school retrofitting is determined by the seismic capacity expressed in Is and q. Basically, the smallest values of the indexes for each floor and each direction (beam and girder directions) are used, although some correction can be made by considering the distribution of the indexes and other indexes, including those for strength and ductility. The urgency level is defined using the chart shown in figure 3.3.

11 The expected seismic capacity is currently in discussion to upgrade such as "buildings should not only be anti-collapse but be kept functional in severe earthquakes."

Figure 3.3: Urgency level determination chart (reinforced concrete school building)



Source: MEXT 2003b.

FIGURE 3.3
Urgency level determination chart (reinforced concrete school building)

The results of seismic diagnosis need to be validated by a third-party organization, namely the Committee on Seismic Assessment Judgment,[12] so that the retrofitting plan can be certified and submitted as evidence for receipt of the national subsidy.

12 The committee needs to comprise more than five members and should include academics of building engineers and a constructional design first-class registered architect.

Step 6: Determine urgency. The priority of projects is discussed by the investigative organization and its subgroup of experts based on schools' earthquake resistance. As a rule, priority should be given to school facilities with a high urgency level that are in danger of collapsing or being badly damaged. MEXT emphasizes the importance of considering making general improvements to school facilities at the same time that retrofitting is carried out.

The urgency levels for RC school buildings, structural steel-framed gymnasiums, and gymnasiums with light precast concrete roofs are determined separately for each type of facility. The investigative committee needs to decide which school facilities among each type should be prioritized by reviewing results of the seismic diagnosis for each facility and taking into consideration each facility's specific needs.

Step 7: Formulate annual plan. Using the list of school facilities to be reconstructed or retrofitted, local governments need to formulate an annual plan for implementing construction. They must first calculate the volume and the necessary costs of the work. Then, taking into consideration the financial situation and other specific needs of the area, they can determine how long the work will take.

MEXT also highlights the importance of ensuring consistency with other facility development projects, setting adequate unit costs for school retrofitting, incorporating school retrofitting into a regional development master plan and a local disaster prevention plan, and disclosing the annual plan to stakeholders.

3.1.2 Reconstruction versus Seismic Retrofitting

School buildings that do not meet seismic standards can be made earthquake-resistant either by reconstruction or retrofit. The local governments, as the responsible authority, have to select which method to employ based on each building's earthquake-resistance capacity and durable period, stakeholders' needs for the school facility, and the costs involved.[13]

Reconstruction is recommended when the seismic diagnosis finds the earthquake resistance capacity to be notably low (that is, when the urgency level is ①, or $Is < 0.3$ or $q < 0.5$), or when the building receives a low score on the vulnerability assessment. Reconstruction is also chosen when significant reinforcement is needed, which might negatively affect the educational activities of schoolchildren, or when the retrofit construction would be extremely difficult. For the structural steel-framed gymnasiums, the retrofit option may be workable even if the urgency is level ① ($Is < 0.3$ or $q < 0.5$). For urgency level ②, the retrofit option is considered.

Any retrofitting approach, MEXT says, must maintain sufficient earthquake resistance capacity in its design by introducing the "importance coefficient" and increasing the magnitude of the earthquake in the design criteria.

There are various construction methods for seismic retrofitting, such as steel-frame bracing, RC shear wall, column reinforcement by steel jacketing or fiber reinforced polymers, and out frame. The decision about which method to use is made by local governments based on the type of structure, actual condition of the building, duration of the construction, costs, etc. MEXT prepares the manual for school retrofitting and collects examples of work on different types of structures, and provides them to local governments as references.

13 MEXT did not explicitly indicate a preference for school retrofitting over reconstruction in the 2003 guideline, but it later indicated that retrofitting, which costs less and requires a shorter construction period, makes sense in light of the need to promptly and efficiently ensure sufficient seismic capacity in as many schools as possible with limited financial resources.

A third option in addition to retrofit and reconstruction is emergency reinforcement; MEXT may suggest this when the building's seismic capacity is quite low and when there is likely to be a significant delay before reconstruction or seismic retrofitting can be started.

3.2 Technical Support to Local Governments

In addition to setting policies and furnishing technical guidelines, MEXT has provided technical support to local government through various means:

Publications. MEXT has published manuals (MEXT 2003a, 2003c, 2008b), references (MEXT 2006), and case studies (MEXT 2008a, 2012) to support local governments' understanding of approaches to school retrofitting. A list of the documents developed by MEXT as well other engineering institutions is posted on the MEXT website (see also table 3.7).

Workshops and meetings with governors. MEXT and MLIT have provided prefectural governors with guidance through national workshops and have conducted 8 regional block-based meetings to disseminate necessary information to municipal governors.

- *Technical training by academics*. MEXT has commissioned academic organizations—such as Japan Building Disaster Prevention Association and Research Institute of Educational Facilities—to conduct more technical-based information dissemination and practical training. The themes of the training have varied to reflect the needs of local governments and the progress of the program.
- *Consultation desk*. To quickly respond to inquiries from local governments or private education institutions about earthquake-resistant school facilities, including basic principles of the program, available national subsidies, and engineering-related issues, MEXT has maintained a consultation desk since 2004.[14] Questions are sent to this desk through e-mail or fax, and answers are returned in kind by MEXT officials or outside experts.

14 The Research Institute of Educational Facilities was originally commissioned to establish the consultation desk but it is now run by MEXT.

Table 3.7: List of major references on school retrofitting

Area	Title
Policy	MEXT. 2003. "Guidelines for Promotion of Earthquake-resistance School Building."
Seismic diagnosis	JBDPA. 2001. Seismic Evaluation and Retrofit (seismic evaluation standard and guideline for retrofit for RC structure).
	MEXT. 2006 "Standards for Diagnosis for Seismic Capacity of Gymnasium" (in Japanese).
Vulnerability assessment	Ministry of Education, Sports, and Culture.. 1985. "Methods of Vulnerability Assessment for Reinforced Concrete Masonry" (in Japanese). (revised version)" (in Japanese).
	MEXT. 2001. "Methods of Vulnerability Assessment for RC School Building and Structural Steel-framed School Building (revised version)" (in Japanese).
Seismic retrofitting	AIJ. 2003. "Survey on Seismic Capacity of School Facilities" (in Japanese).
	AIJ. 2003. "Survey on Seismic Retrofitting of School Facilities" (in Japanese).
	AIJ. 2003. "Survey on Seismic Inspection of Nonstructural elements of School Facilities" (in Japanese).
	MEXT. 2003. "Manual of Seismic Retrofitting of School Facilities (for RC School Building) Revised Edition 2003" (in Japanese).
	MEXT. 2003. "Manual of Seismic Retrofitting of School Facilities (for Structural Steel-framed Gymnasium) Revised Edition 2003" (in Japanese).
	MEXT. 2006. Seismic Retrofitting Quick Reference, School Facilities that Withstand Earthquakes – Examples of Seismic Retrofitting.
Retrofitting of Non-structural elements	MEXT. 2010. "Protecting Children from Falling and Tumbling Objects due to an Earthquake"
	MEXT. 2012. "Countermeasures against Fallen Objects in Gymnasium" (in Japanese).
	MEXT. 2012. "Case study of Retrofitting of Nonstructural elements of School Facilities" (in Japanese).
	MEXT. 2015. "Guidebook for Earthquake Protection for Non-structural elements of School Facilities."
Emergency retrofitting	Ministry of Education, Science and Culture. 1999. "Manual of Emergency Restoration of School Facilities" (in Japanese).

Tsunami protection	MEXT. 2014. "Ideal State of Disaster-Resilient School Facilities –Tsunami protection measures and enhancement of disaster prevention function as evacuation shelter–"
Financing measures	MEXT. 2008. "PFI Manual for Seismic Retrofitting of Public Schools" (in Japanese).

3.3 Financial Support to Local Governments

The main financial scheme prepared by MEXT is the special provision of subsidies for reconstruction and seismic retrofitting of school building structures and nonstructural elements. To further accelerate the program, MEXT has urged the use of fiscal measures by local governments, namely local bonds and local tax allocation, and introduced a private finance initiative (PFI) for seismic retrofitting of public schools. These are briefly described below. In addition, MEXT has made available to local governments a complete list of funding mechanisms prepared by other agencies (such as the Cabinet Office, Fire and Disaster Management Agency, MLIT, and Fisheries Agency) that can be used for seismic retrofitting and functional strengthening of schools.

3.3.1 National Subsidies

As described in section 1.3, major educational expenditure is shared between the national government and local governments. The national government provides local governments with additional subsidies for seismic retrofitting and reconstruction of schools with insufficient seismic capacity. In principle, national subsidies for retrofitting and reconstruction cover one-third of associated costs for public elementary and junior high schools, but the national share has been raised to two-thirds and one-half respectively by the Act on Special Measures for Earthquake Disaster Countermeasures (see table 3.8). This is a time-limited measure, but the period has been extended repeatedly and currently expires on March 31, 2021. The subsidies can be used for vulnerability assessment, seismic diagnosis and retrofit planning, design of construction, and outsourcing of construction management, in addition to the construction itself.

Table 3.8: Principle and special provision of national government subsidies as of 2015

<table>
<tr><td colspan="3" rowspan="3">Level of schools, types of construction, and targets of construction</td><td rowspan="3">Principle</td><td colspan="2">Special provision</td></tr>
<tr><td colspan="2">Act on Special Measures for Earthquake Disaster Countermeasures</td></tr>
<tr><td>Is < 0.3</td><td>Is ≥ 0.3</td></tr>
<tr><td rowspan="5">Elementary school, junior high school, and lower level of secondary school</td><td rowspan="3">Retrofitting</td><td>Classroom buildings</td><td>1/3</td><td>2/3[a]</td><td>1/2</td></tr>
<tr><td>Gymnasium</td><td>1/3</td><td>2/3</td><td>1/2</td></tr>
<tr><td>Student housing</td><td>1/3</td><td>2/3</td><td>n.a.</td></tr>
<tr><td rowspan="2">Recon-struction</td><td>Classroom buildings</td><td>1/3</td><td>1/2[b]</td><td>n.a.</td></tr>
<tr><td>Gymnasium, student housing</td><td>1/3</td><td>1/2[b]</td><td>n.a.</td></tr>
<tr><td rowspan="2">Special-needs school (kindergarten, elementary, junior high school), kindergarten</td><td>Retrofitting</td><td>Classroom buildings, Gymnasium, student housing</td><td>1/3</td><td>2/3</td><td>n.a.</td></tr>
<tr><td>Recon-struction</td><td>Classroom buildings, Gymnasium, student housing</td><td>1/3</td><td>1/2</td><td>n.a.</td></tr>
<tr><td rowspan="2">Special-needs school (senior high school)</td><td colspan="2">Retrofitting</td><td>1/3</td><td>n.a.</td><td>n.a.</td></tr>
<tr><td colspan="2">Reconstruction</td><td>1/3</td><td>n.a.</td><td>n.a.</td></tr>
</table>

Source: MEXT, 2015, "About Government Subsidy Programs"

Note: n.a. = not applicable.

a. The proportion of the national government subsidy was increased to 2/3 from 1/2 in the 2008 revision of the Act on Special Measures for Earthquake Disaster Countermeasures.

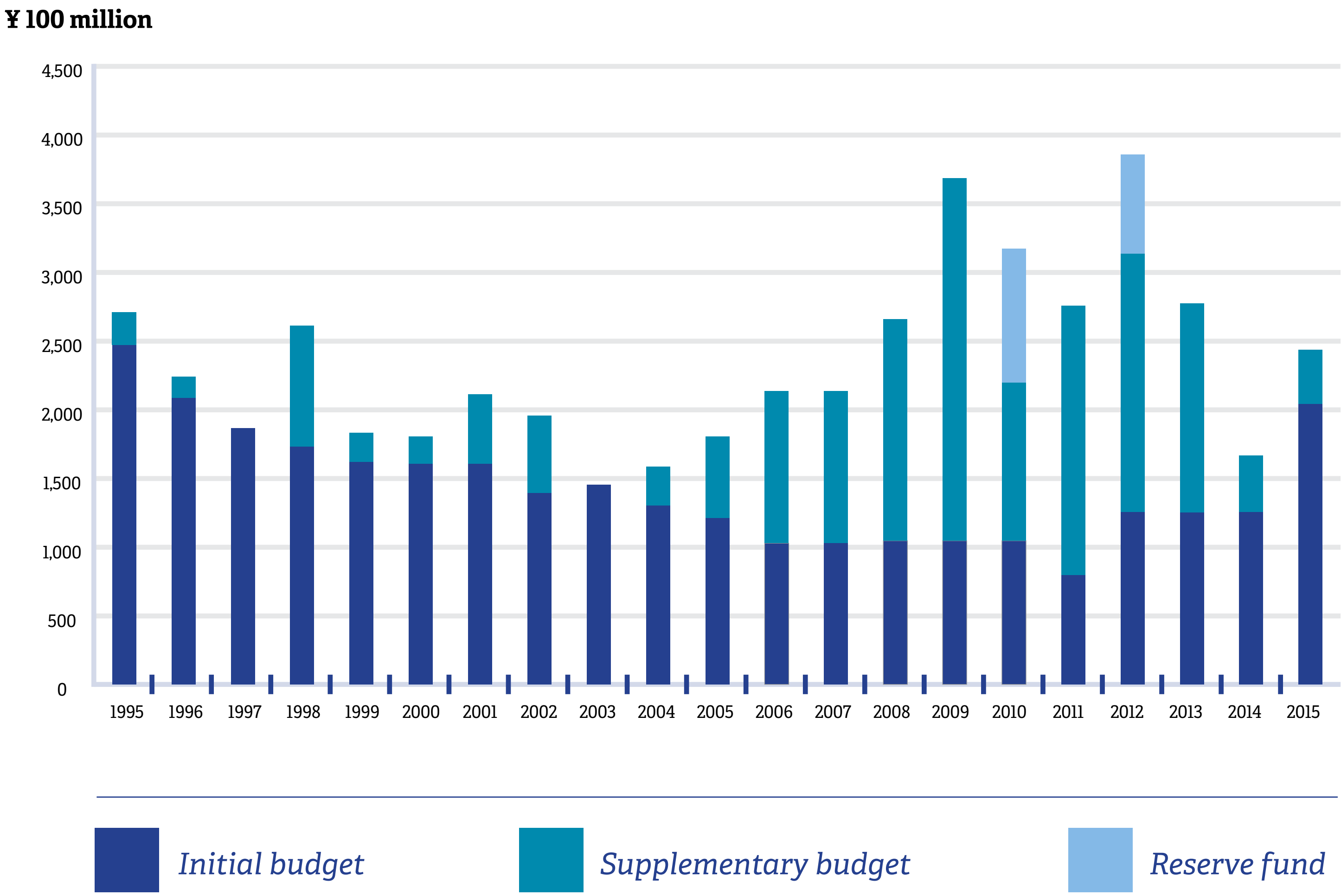
b. The proportion of the national government subsidy was increased to 1/2 from 1/3 in the 2008 revision of the Act on Special Measures for Earthquake Disaster Countermeasures.

The subsidies prepared for the program were part of MEXT's school facility development budget. Figure 3.4 shows the total annual facility development budget for new construction, reconstruction, rehabilitation, and seismic retrofitting for public schools. As shown in the figure, the budget had decreased over years before the program started; this was due to the gradual decrease in the number of schools. After the commencement of the program in 2003, the total budget increased dramatically until 2009 and showed variation after that [15].

What is interesting to note is that the budget increases were mainly covered by the supplementary budgets, shown as the teal bars in the figure. The supplementary budget is meant to be used to prepare for unexpected disasters, but in practice, it is often utilized to expand government expenditures and compensate for the deterioration of the economy. The supplementary budget needs to be determined as quickly as possible at the end of the fiscal term and requires only six days of discussion in the Diet, which makes approval easier.

As local governments' demands for national subsidies for school retrofit increased, it became difficult for MEXT to secure sufficient amounts in the initial budget. Members of the Diet, particularly members of the Committee on Education and Science, supported a budget increase for the program and asked the Minister of Finance to allocate sufficient budget for seismic retrofitting of school buildings using the supplementary budget. They have also urged the government to use the reserve fund, which is set aside as a contingency fund and usually left unused.

15 The variation in the budget after 2009 may be attributed to the change of government and aftermath of the Great East Japan Earthquake occurred in 2011.



Source: MEXT 2015.
Note: Data from 2004 onward is limited to budgets related to seismic reconstruction and retrofitting. Data before 2004 shows the total budget for facility development. Figures include budget for kindergartens, elementary schools, junior high schools, and special-needs schools.

FIGURE 3.4
Facility development budget for public elementary and junior high schools

Construction for school retrofit needs to be conducted during the summer school holidays in July and August to avoid negative impacts on educational activities. In order to meet this schedule, the budget needs to be approved in the "first" supplementary budget, preferably within April of the same year. Such a demand from local governments has also placed pressure on the central government to allocate funds for seismic retrofitting of school buildings.

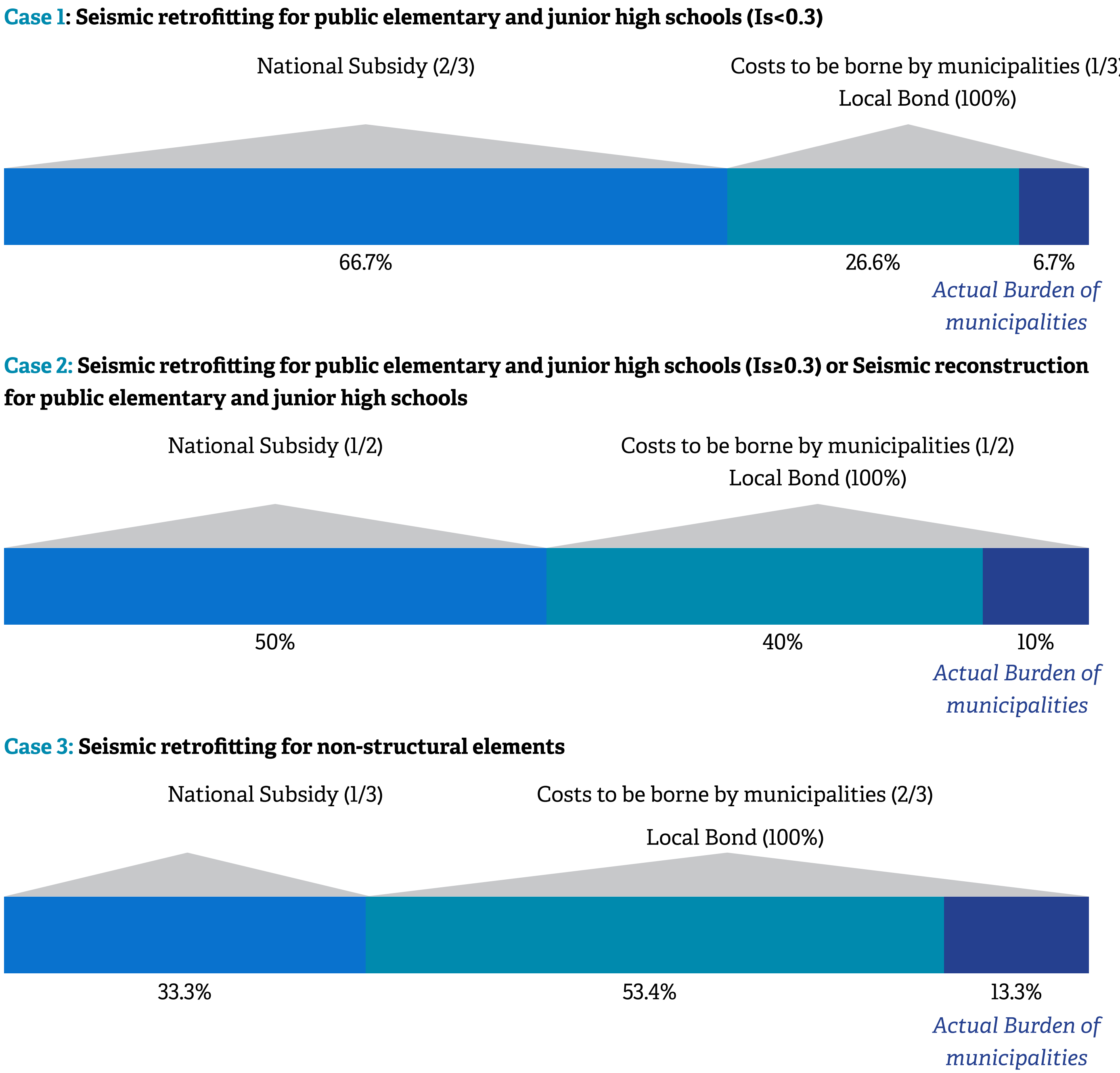
3.3.2 Local bonds and Local Tax Allocation

In addition to the national subsidies described above, another source of program funding comes from fiscal measures for local governments, namely, local government bonds and local tax allocation. Local governments are permitted to issue local bonds only to raise financial resources for public enterprises (such as transportation, gas, and water) and infrastructure development.

As a general rule, the local tax allocation can be allocated to cover two-thirds of the redemption of principal and interest.[16] In the case of seismic retrofitting and reconstruction, 80 percent of the costs can be covered by the local tax allocation. This makes the actual financial burden of municipalities relatively small: 6.7 percent for seismic retrofitting (when Is < 0.3) and 10 percent for seismic reconstruction (as shown in figure 3.5).

Such fiscal measures using the local tax allocation were originally limited to specific areas that had financial difficulties, but they have been nationwide since FY2007.

16 Local tax allocation is granted to fill the financial gaps of local governments and to ensure the sufficient size of the general account budget for local governments whose local tax revenue is not large enough. The amount of the local tax allocation is based on the size of the local government's budget deficit, which is calculated with the amount of redemption of principal and interest of the local government bonds.



Source: Based on MEXT, 2015, "Financial support measures for school retrofitting of public elementary and junior high schools."
Note: This financial scheme is based on the special account for reconstruction, which is a time-limited measure.

FIGURE 3.5
Example of fiscal measures for seismic reconstruction and retrofitting as of FY2015

3.3.3 Private Finance Initiative

In light of regional disparities in the progress of school retrofitting, MEXT proposed the use of a private finance initiative. In 2008, it developed and disseminated PFI manuals (e.g., MEXT 2008c) focusing on seismic retrofitting and reconstruction of public schools.

PFI was considered an effective way to cope with problems commonly experienced by local governments, including limited financial resources, a large number of buildings needing retrofit or reconstruction, and a lack of local government engineers. The idea was that PFI would (1) reduce fiscal spending through use of a blanket order; (2) equalize annual fiscal spending of local government over the years with the use of private financing; (3) reduce the workload of local government staffs (by reducing the need to place orders and make contracts); and (4) accelerate school retrofitting through a blanket order covering many schools at the same time.

In practice, however, the use of PFI by municipalities was limited—not because the scheme was not functional, but because unfamiliarity with the scheme made municipalities hesitant to adopt it. Another possible reason why use of PFI was limited was that by the time the manual was disseminated, urban municipalities had already retrofitted most of their schools.

3.4 Monitoring of Progress

MEXT has closely monitored the progress made under the program by collecting information from local governments. The quantitative data are collected from the annual survey on the Status of Seismic Resistance of Public School Facilities. The qualitative data, such as information on difficulties faced by local governments or on good practices, are collected periodically through the questionnaire survey for local governments.

MEXT uses these data to understand the overall progress of the program and take necessary measures in response. Early on, when progress was slow for many local governments, MEXT tried to identify common problems and to provide solutions—that is, prepared alternative financial schemes, developed practical manuals, and held seminars. When regional differences became evident, MEXT prepared an information sheet on good practices for prefectural and municipal governments, including detailed accounts of how some municipalities overcame problems. Such information was publicly shared and helped to promote mutual learning among local governments.

MEXT has also ranked municipalities by the percentage and the number of earthquake-resistant schools, an approach that has encouraged lagging municipalities to work more quickly. The minister of MEXT wrote directly to mayors of lower-ranking municipalities to urge prompt action, and MEXT officials visited them to provide specific guidance. Such careful monitoring and feedback by MEXT has played an important role in promoting the program.

3.5 Challenges

In the course of developing and carrying out the program, MEXT has faced and sought to meet various challenges, both at the central and local government levels. Challenges relating to human resources, finance, and technology, among others, some of which have been described above, are summarized in table 3.9 along with countermeasures taken to address them.

Table 3.9: Challenges faced by MEXT and responses

Categories	Challenges	Countermeasures taken
Human resources	• Lack of initiative in leaders of local governments	• Publicly disclosed (in annual press release) ranking of prefectures and municipalities in progress toward earthquake-resilient schools • Minister wrote directly to lagging municipalities to demand acceleration of projects
	• Lack of technical staff at the local government level who are knowledgeable about seismic evaluation and retrofitting	• Prepared manuals, quick guides, and collections of cases • Conducted (or commissioned third parties to conduct) training programs in different parts of the country targeting both local government officials and architects in private firms • Used those who completed the training as "expert engineers" in dissemination of the retrofitting methods
Finance	• Financial burden on the local governments, which led to slow progress by the program	• Increased the national subsidies in seismic retrofitting and reconstruction • Frequently introduced various financial schemes, including funding from other ministries with detailed manuals
	• Difficulty in securing sufficient funding for retrofitting subsidies from the initial national budget	• Explored the use of supplementary budget and reserve fund
Technical	• Failure to clearly establish guidance for institutional arrangements and technical specifications (for nonstructural elements of school buildings)	• Implemented pilot projects with municipalities to establish a method in different parts of the country
Others	• Disparities in progress among prefectures (and municipalities)	• Visited the municipalities that were slow and provided advice and consultation for individual municipalities • Conducted both quantitative and qualitative monitoring to better understand problems faced by local governments, and took measures to solve them

Chapter 4
Program Implementation and the Role Played by Local Governments

In Japan, the main players in implementing the Program for Earthquake-Resistant School Buildings are the local governments, which are the authorities responsible for public schools. Following the steps described in the Ministry of Education, Culture, Sports, Science and Technology (MEXT) guidelines, they plan retrofitting projects for their schools and implement necessary construction. How stakeholders in local governments act and collaborate at each step is described in this chapter, with reference to particular challenges and good practices.

4.1 Planning

4.1.1 Prefectural Governments

In line with the government hierarchy, the prefectural governors' role has mainly been to (1) guide the municipal governors in applying the national subsidies and supervise the process with MEXT's guidance and advice, (2) give the mayors the technical support needed to implement the program with MEXT, the Ministry of Land, Infrastructure, Transport and Tourism, and academic organizations, and (3) collect program data from municipal governments and report the results to MEXT.

To ensure that they can carry out these roles, the prefectural governors have the opportunity to attend the annual meetings and periodic workshops held by MEXT, where they can acquire the knowledge of guidelines and applications needed to promote the program both technically and financially. Most prefectural governors attend national annual meetings in the central region that address general issues, as well as several workshops targeting blocs of prefectures with more detailed engineering information.

In addition, prefectural governors have various chances to get more specified technical knowledge from groups in academia; the Japan Building Disaster Prevention Association (JBDPA), for example, shares advanced data and knowledge about seismic retrofitting, and coordinates the key players in disaster prevention in the public, private, and academic sectors. Based on this knowledge, prefectural governments are expected to give instructions to municipal governments through local meetings or e-mail, depending on the type of issue. Such a system of knowledge transfer has worked quite effectively to promote the program nationwide.

Simultaneously, prefectural governments are responsible for the seismic retrofitting of high schools and prefectural universities (though not kindergartens, elementary schools, or junior high schools, which are the responsibility of municipal governments). Prefectural governors sometimes lead in implementing the seismic retrofitting projects ahead of municipalities, and then give directions and suggestions to the mayors based on their experience. The procedure for the seismic retrofitting projects is the same at the prefectural level and the municipal level. It is described in the next section.

4.1.2 Municipal Governments

The municipal governments carry out the program steps as described in chapter 3, namely (1) establishing steering committees for the program; (2) implementing basic surveys; (3) implementing and assessing the prioritization of vulnerable school buildings; (4) determining the vulnerability assessments; (5) implementing seismic diagnosis; (6) discussing the urgency of projects based on the seismic resistance evaluation; and (7) formulating an annual plan to make school buildings earthquake-resistant. As figure 4.1 shows, the municipal governments have responsibility for all of the processes in that they must get support from relevant private sector stakeholders at each step, though the task demarcation among the stakeholders and the level of involvement slightly vary by municipality.

	Procedures of School Retrofitting Program Planning and Implementation	General Affairs Dept., Board of Education	Architecture Dept., Municipal Govt.	(Association of) Architecture Firms	Construction Confirmation Firms (3rd Party)	Schools/ Community
PLANNING	Step 1: Establishment of Investigative Organization	Involved	Partially Involved	Partially Involved	Not Involved	Not Involved
PLANNING	Step 2: Implementation of Basic Survey	Involved	Partially Involved	Partially Involved	Not Involved	Not Involved
PLANNING	Step 3: Prioritization of Vulnerable Buildings for Seismic Retrofitting	Partially Involved	Involved	Involved	Involved	Not Involved
PLANNING	Step 4: Vulnerability Assessment	Partially Involved	Involved	Involved	Involved	Not Involved
PLANNING	Step 5: Implementation of Seismic Diagnosis	Partially Involved	Involved	Involved	Involved	Not Involved
IMPLEMENTATION	Step 6: Determination on Urgency of the Projects	Involved	Partially Involved	Not Involved	Not Involved	Partially Involved
IMPLEMENTATION	Step 7: Formulation of Annual Plan	Involved	Partially Involved	Not Involved	Not Involved	Not Involved
IMPLEMENTATION	Step 8: Formulation of Reinforcement Plan	Partially Involved	Involved	Involved	Partially Involved	Partially Involved
IMPLEMENTATION	Step 9: Preparation of Design Drawings	Partially Involved	Involved	Involved	Partially Involved	Partially Involved
IMPLEMENTATION	Step 10: Implementation of Construction Works	Partially Involved	Involved	Involved	Partially Involved	Partially Involved

Involved *Partially Involved* *Not Involved*

General Affairs Dept., Board of Education

- *Takes initiatives for the program at municipality level*
- *Responsible for managing all school retrofitting projects, inclusive of fundraising and allocation*
- *Might ask support from Architect Dept. for technical procedures*

Local Governments

- *Responsible for technical assessments and arranges contracts with architectural firms*
- *Close communication with General Affairs Dept. of BOE*

Source: Based on interviews with local governments by the survey team (2016).

FIGURE 4.1
Responsibilities of local governments and other local stakeholders for program planning and implementation

4.1.3 Roles and Responsibilities of Stakeholders at Municipal level

In general, municipal governments get effective support from their prefectural governments, as mentioned above. Municipal governments have opportunities to deepen their understanding of technical, financial, and administrative procedures and guidelines by attending workshops held by the prefectural government, as well as through periodic flexible consultations. Some municipalities have also consulted with MEXT directly to ensure effective use of national subsidies.

In any case, successfully promoting earthquake-resistant schools requires strong action on the part of municipal government leaders, whether mayors or municipal assemblies. Such initiatives also involve the active participation of various stakeholders, such as the prefectural governor, the prefectural assembly, and MEXT. This strong, layered structure has served the program well.

The different sections/departments under the municipal governments are in charge of the various steps involved in carrying out the program, as explained below. Job demarcations are clear, though these change slightly depending on the availability of human resources. In general, the general affairs department of the board of education (BOE) takes the initiative for the whole process and coordinates the stakeholders involved.

The general affairs department has administrative staff and some technical staff, including staff in architecture, civil engineering, electrical engineering, and facility management. The technical staff is often limited, however, so support is sometimes sought from the municipal architectural department (which might go under a different name). The architectural department usually works closely with the general affairs department (in the same government building; see box 4.1 for a brief description of its responsibilities). In addition, in some cases, the general affairs department asks for initial consultations with a private architectural firm or a local association of architectural firms.

BOX 4.1: SAMPLE TASKS OF ARCHITECTURAL DEPARTMENT IN A MUNICIPAL GOVERNMENT

- Designing, and supervising construction of public buildings
- Devising disaster prevention measures; seismic retrofitting of buildings
- Planning policies related to housing
- Constructing and managing municipal housing
- Certifying good-quality housing
- Handling transfer operations for housing in hazardous areas
- Handling permission, approval, and authorization of building construction
- Taking measures to prevent illegal architecture
- Investigating road conditions

Step 1: Establishment of steering committee. The steering committees for the program have been established under the BOE directly, or under the general affairs departments of BOE. Since the early 2000s, when MEXT strengthened initiatives under the program, it has been easier for municipal BOEs to allocate more human resources to the committee. Some municipalities were even able to create a new division specifically for promoting the program, having been given the authority for all the related procurements from the finance divisions. Even before the 2000s, some general affairs departments of BOEs flexibly formed such committees by using their own relationships with local resources, such as associations of architectural firms and academic experts. In areas at high risk of earthquake, the prefectural governors have formed strong initiatives that led to prefectural BOEs strictly monitoring and being involved with the municipality-level committees.

Step 2: Implementation of Basic Survey. The steering committees implement the basic survey (as described in section 3.1.1 and table 3.1) In most cases, the general affairs department of the BOE is able to handle these tasks by itself without outsourcing to any firms.

Step 3: Prioritization of Vulnerable Buildings for Seismic Rehabilitation. The steering committee implements prioritization of vulnerable building for reconstruction or seismic retrofitting in order to determine priority for the vulnerability assessment or seismic diagnosis (procedures are described in section 3.1.1). This assessment must be carried out for buildings maintained under the old building standards, although the process could be omitted if (1) the municipality has a small number of schools and it is not necessary to prioritize them, or (2) the earthquake capacity is identified by the first diagnosis for low-rise buildings with wall structures.

The steering committees sometimes ask for technical contributions from the architectural department (or from a civil engineering or facility-related department). If this support is not enough, they outsource some surveys to associations of local architectural firms. There are two patterns of outsourcing, one in which a single firm handles all the surveys, and one in which different firms handle different surveys. The former procedure can ensure that data are unified, comparable, and to the same standards, while the latter cannot.

Step 4: Vulnerability Assessment. Based on the results of the prioritization assessment, the seismic diagnosis or the vulnerability assessment is sequentially implemented to school buildings of high priority (as described in section 3.1.1). If the building's concrete strength is low and the reinforcing steel bar and structural steel are widely corroded, the school buildings' vulnerability is assessed. This process can also be outsourced to architectural firms or to academic professionals if necessary. Because of its technical knowledge, the municipal architectural department (or civil engineering or facility-related department) is in charge of outsourcing and managing the contract rather than the general affairs department of the BOE.

Step 5: Implementation of Seismic Diagnosis. Based on the results of the prioritization assessment or the vulnerability assessment, assessment of seismic resistance capacity is implemented using the technical procedures described in section 3.1.1. With the results of the seismic diagnosis, the buildings are categorized into three types: (1) buildings with Is lower than 0.3, or q lower than 0.5, which are to be reconstructed; (2) buildings with Is between 0.3 and 0.7, or q between 0.5 and 1.0, which are to be reinforced; and (3) buildings with Is greater than 0.7, and q greater than 0.9, which have low need for reinforcement.

Beyond these guidelines, some municipalities with a high risk of earthquake have set their own rules, stricter than those set by MEXT. In such cases, the prefectural governments (prefectural BOEs) have strong incentives to ask the municipal BOEs to accelerate the evaluation and submit reports from time to time. In Japan, especially in rural areas, many schools were built before 1981 when the new standards were enforced, and reconstruction has seemed highly necessary.

The seismic diagnosis process can be also outsourced to architectural firms or to academic professionals if necessary, possibly through the architecture-related departments of municipal governments.

Step 6: Determination of Urgency of the Projects. The steering committee considers the urgency of projects based on the results of seismic resistance evaluation and according to the urgency level determination chart (figure 3.3). In other words, the steering committees determine which school buildings are to be reconstructed or retrofitted. To make these decisions, they consider the buildings' earthquake-resistance capacity and durable period, the needs of parties concerned for the school buildings, costs necessary for the projects, and so forth.

In the process, the steering committees investigate if the judgments are in compliance with the Building Standards Law, the Fire Defense Law, and other laws and regulations in force; if there are any plans for school merger/closure or diversion; whether the buildings have historical importance; and whether there are plans for municipality mergers. Furthermore, the committees should consider relevant functional improvements to buildings. Thus the steering committee, including both the general affairs department of the BOE and the municipal architectural department (or civil engineering/facility-related department), sometimes inclusive of local architectural firms, need to have a series of meetings with schoolmasters and communities to explain their plan and get consensus at this stage of implementation. Schoolmasters and communities may offer various opinions, but the municipal governors have the final authority to decide based on the results of the assessments.

Step 7: Formulation of Annual Plan. The steering committees formulate a yearly plan—one considering costs and schedule—to make school buildings earthquake-resistant. When the steering committees prioritize the vulnerable school buildings, they should consider multiple viewpoints based on the seismic resistance assessment results and the schools' needs. They should also keep in mind the local political situation and the overall municipal development plan. The municipal governors set the rules by themselves and describe the entire plan.

The costs of each project, as calculated by technical experts, are considered. At this stage, the most important role for the administrator is securing a sufficient budget for the projected costs. Basically, finance for earthquake-resistant schools is managed by national subsidies, local bonds, and municipal taxes, as described in sections 3.3.1 and 3.3.2.

4.2 Implementation

4.2.1 Implementation processes

After the planning stage, the steering committees continuously coordinate the implementation process. The main steps are formulating a seismic reinforcement plan ("preliminary design," in technical terminology) to identify possible seismic retrofitting construction methods and seismic performance of structures with the proposed methods (step 8); preparing design drawings that specify appropriate construction methods, schedules, and costs (step 9); and implementing the seismic retrofitting construction works by building contractors (step 10). In most cases, the steering committees outsource these three steps to the private sector (architectural and construction firms), though they are responsible for both technical and administrative management. Procurement procedures are described in more detail in box 4.2.

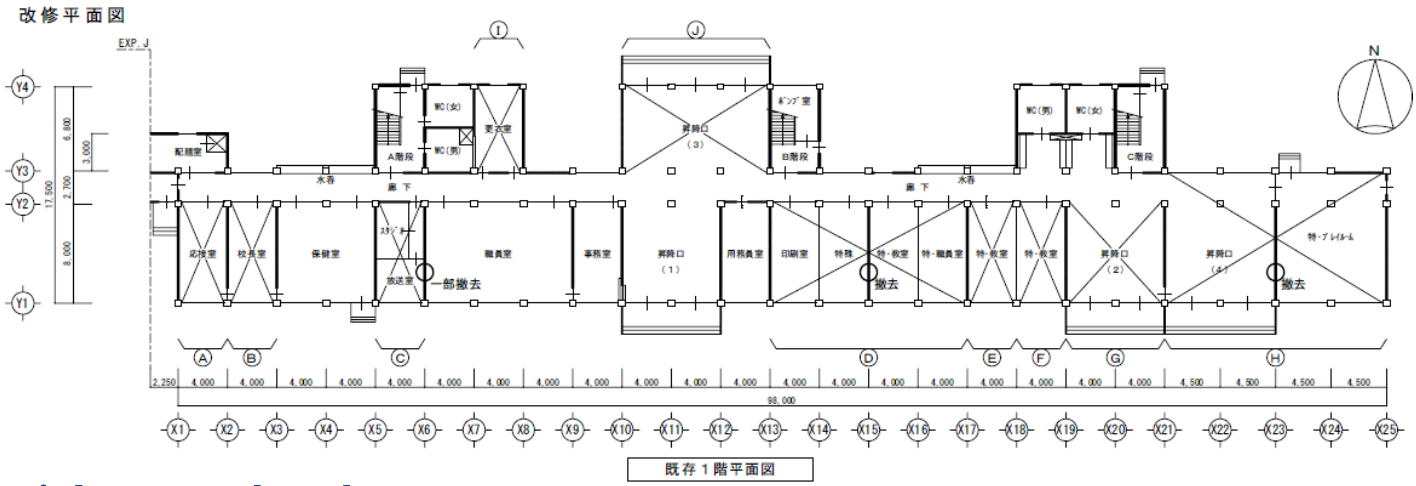
*Step 8: Formulation of Seismic Reinforcement Plan ("preliminary design").*The steering committees investigate the performance of structures using the results of seismic evaluation. The committee architects or outsourced architectural firms identify which retrofitting construction methods would be effective for each part of the structures, and calculate earthquake resistance of the retrofitted body expected to be strengthened by each method.

The major seismic retrofitting methods are listed in the manuals on seismic reinforcement of school facilities that have been produced and revised by MEXT.[17] The steering committees could refer to these manuals, or could simply choose the methods proposed by the firms. The most frequently used methods involve reinforced concrete (RC) wall and steel-framed brace. It is important for the steering committees at this stage to hear from users such as schoolmasters about the merits and demerits of particular methods and about how the construction schedule affects the annual education plan. This perspective should be included in the seismic retrofitting plan to ensure it meets users' needs.

Step 9: Preparation of Design Drawings specifying construction methods, schedule, and costs. The steering committees then prepare design drawings specifying which construction methods to use in each section of the building (samples are shown in figure 4.2). The committee architects or outsourced firms draw a detailed seismic retrofitting design with the selected construction methods, show the expected construction schedule, and estimate the construction costs. During this process, the committee again solicits opinions from schoolmasters, parent groups, local residents, and local assemblies—both informally and formally—to make the plan more effective and acceptable to schools and architectural design firms.

17 Manuals published by JBDPA are also relevant.

Existing Floor Plan



Reinforcement Floor Plan

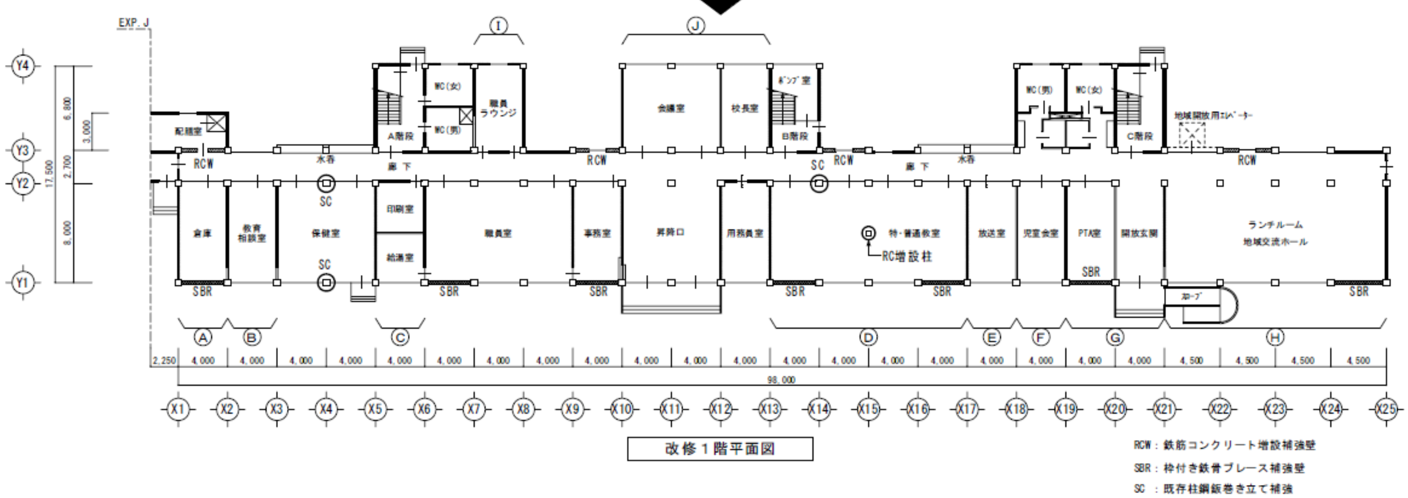
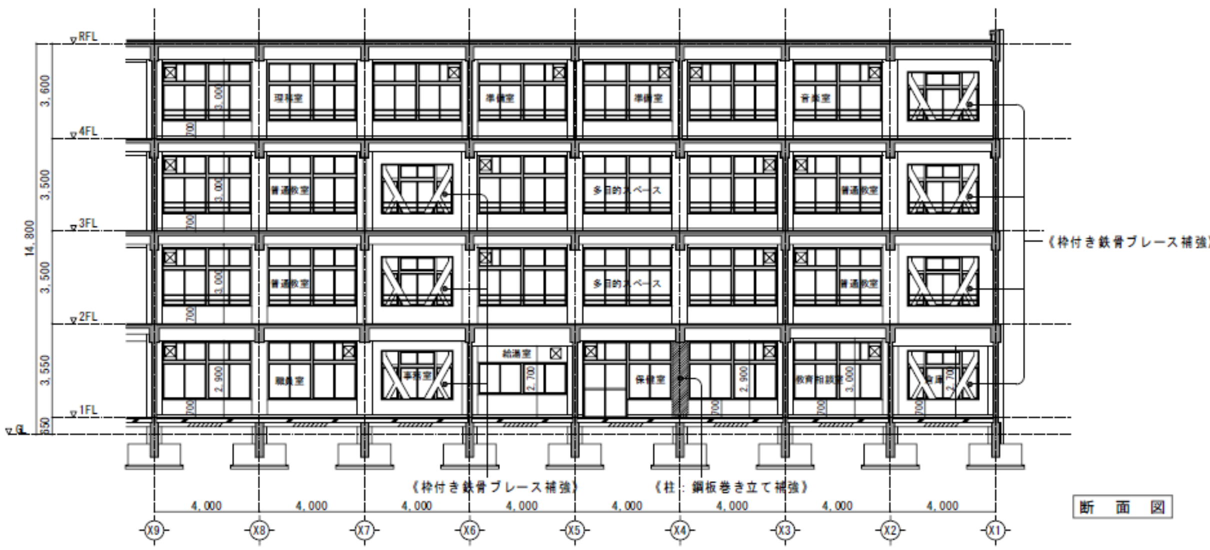


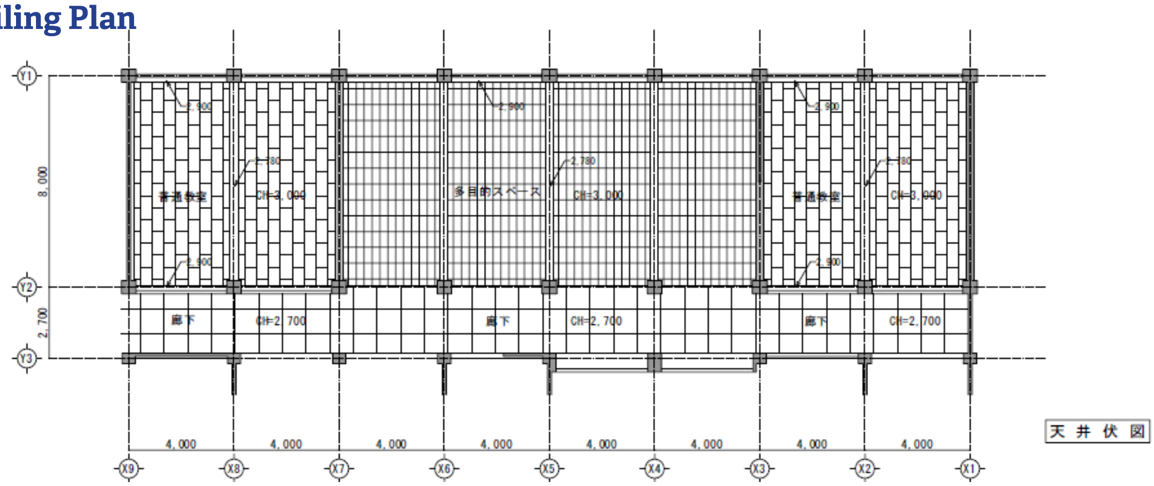
FIGURE 4.2
Examples of seismic retrofitting design drawings

Cross Section

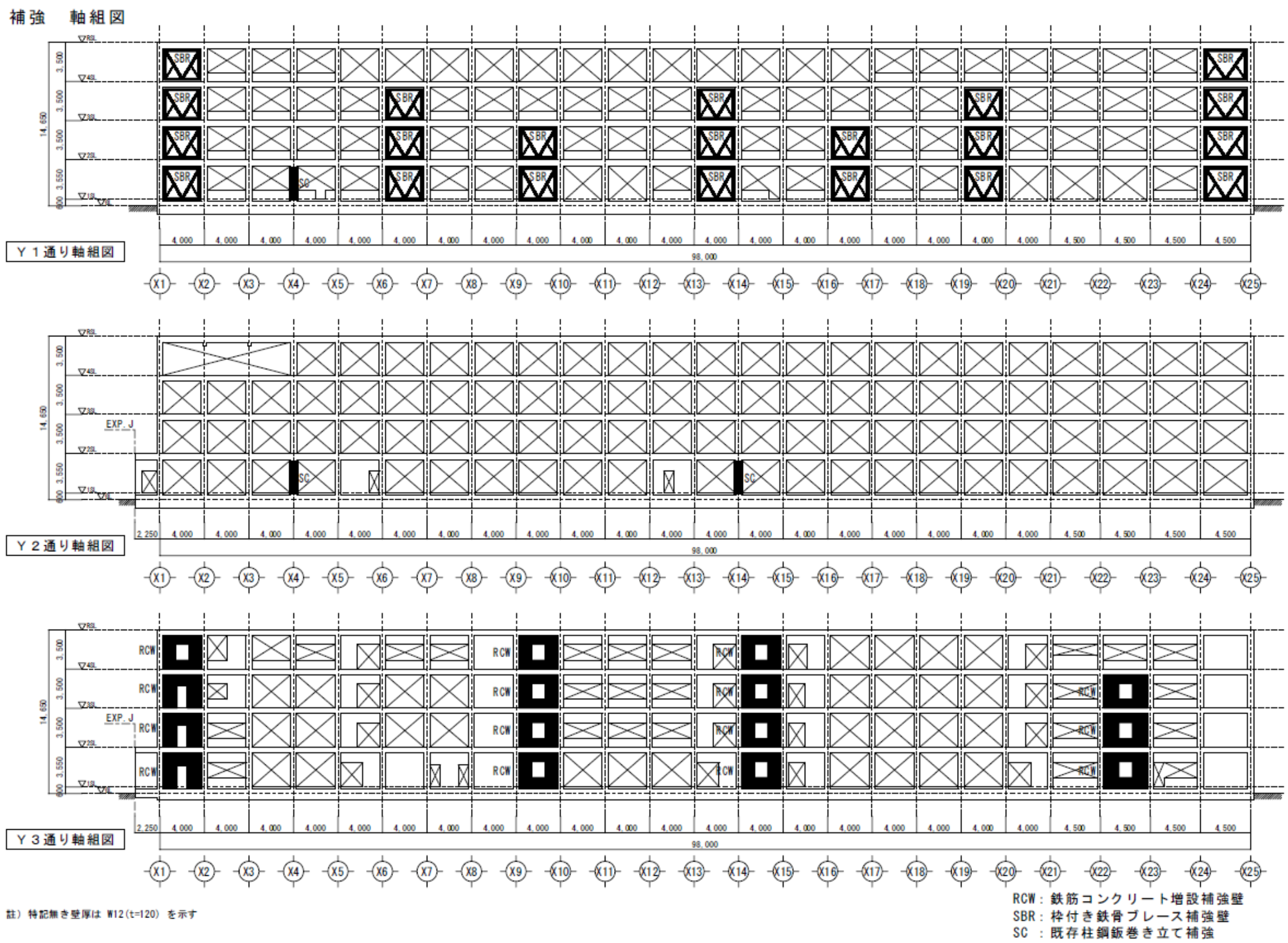
断面図・天井伏図



Reflected Ceiling Plan



Reinforced Framing Evaluation



Source: NIER 2005.

RCW: Reinforced concrete walls
SBR: Steel-framed brace

Regarding the work schedule, the committees try to minimize the effect of construction on school activities, so much of the work is scheduled for the summer vacation in July and August; in general the work has taken place from June to September, or on weekends or after school. During the school year, quiet work tasks, such as painting, are implemented, monitored by the security guards. Thus, in most cases, work does not affect school activities.

Projects can take half a year to several years, depending on the type of work; but in general they are planned to take as little time as possible. For reconstruction work that will take several years, temporary facilities are built before the summer vacation, and all school functions take place there until the completion of the project.

Step 10: Implementation of Seismic Retrofitting Construction Works. The steering committee contracts the works with the completed construction design to building contractors, usually located in the municipality. The steering committee, particularly the local government's technical body, takes the initiative for this process. If the municipality has a shortage of firms, it flexibly works with those in the surrounding area. The bid methods depend on municipalities. Construction management is quite important for ensuring the quality of retrofitting, so the steering committees take care of management responsibilities during construction.

In general, the bids for the construction works commence in April, and works begin in May. During the preparation period, the contractor proceeds with site investigation, designs RC walls and steel-framed braces, and orders materials. If needed, external scaffolding is built during weekends in June, and the retrofitting construction works of facilities and equipment commence in July.

The municipalities also take care of students' safety during the construction period. The construction area is surrounded by fences and monitored by security guards. Both administrative and architectural staff as well as the building contractors visit schools and explain the earthquake-resistant retrofitting/reconstruction plan to schoolmasters. This process occurs before schools plan their next annual schedule, i.e., by every March. The steering committee explains the types of construction, the places that need to be retrofitted, the length of construction, and so forth.

For each of the three steps of the implementation process, the steering committees manage smooth implementation by communicating/negotiating with architects, building contractors, schools, and community residents. Moreover, as they include staff of the government authority responsible for schools, they are responsible for routine checks on school facilities and equipment. They maintain school facilities and equipment by carrying out inspections, repairs, and regular maintenance. It is particularly important to regularly check ceiling materials, equipment, and apparatus, as well as installed machines and nonstructural elements whose seismic capacity is doubtful, and to consider them in the appropriate improvement plan. The Architectural Institute of Japan has published relevant manuals for these considerations.

BOX 4.2: PROCUREMENT IN SEISMIC REINFORCEMENT PROJECTS IN JAPAN

Three steps in the planning stage—prioritization of vulnerable buildings for seismic rehabilitation (step 3), determination of the vulnerability assessment (step 4), and implementation of seismic diagnosis (step 5)—are usually implemented by third-party architects and construction firms contracted through a bidding process. Three steps in the implementation stage—formulation of a seismic reinforcement plan (step 8), preparation of design drawings (step 9), and implementation of seismic retrofitting construction works (step 10)—are usually implemented in the same way. The construction firms bid for step 10, while architectural firms with registered seismic reinforcement experts bid for the others. Most municipalities plan and undertake the procurement process over three years: procurement of steps 3, 4, and 5 occurs in the first year, of steps 8 and 9 in the second year, and of step 10 in the third year. This is because local governments need to plan and establish the necessary budget for the three main processes yearly under financial administration rules; governments can then flexibly proceed with the work stage by stage within their limited budget.

Procurement procedures and content are mostly uniform nationwide, but each local government sets its own guidelines and forms to follow (these are prepared for general use, not only for the seismic retrofit projects). The municipalities can invite bidding on a series of projects—as many as 10 schools needing retrofit can be handled together—but only if they expect that big local firms could implement such projects. More commonly bids are on a single school-based project for budgetary and efficiency reasons.

An interesting feature of the procurement procedure is its localization. The main bidders are local architectural/construction firms, and the bidding process is prioritized for them. Furthermore, some seismic trading companies and staff agencies that specialize in retrofit actively work in each region, with the construction works frequently done during the summer vacation season. It is noteworthy that the seismic retrofit projects indirectly create the sort of business opportunities where specified resources are necessary, and have even contributed to regional economic development in Japan.

4.2.2 Financing

The steering committees are responsible for securing sufficient budget for all planning and implementation processes. As shown in chapter 3, special provision is made for national subsidies for seismic retrofitting and reconstruction of school buildings. To the extent possible, MEXT gives preferential treatment to economically disadvantaged local governments in rural area to address their lack of funds.

The merits of the national subsidy are that (1) the local governments can choose the projects to carry out in line with their plan of facility maintenance; (2) they can change the volume of projects to carry out every fiscal year according to the progress of the projects; and (3) they can utilize the subsidy beyond the projects. This flexible subsidy system has encouraged local governments to pursue seismic retrofitting and reconstruction in spite of the attendant difficulties of administration.

Even with the national subsidies, however, limited budgets have posed a substantial challenge to local governments. In most cases, the basic survey showed that many school facilities needed retrofit, and that some facilities—constructed before the revision of the Building Standards Law in 1981—needed complete reconstruction, which resulted in high costs. Coming up with the necessary funding was therefore the toughest stage for the municipal staff.

In areas with relatively high risk of damaging earthquakes, prefectural governments tend to prepare subsidies for reinforcing public facilities, including schools. In Shizuoka Prefecture, for example, where estimates of earthquake probability are high, the local government asked permission from the local chamber of commerce to increase the corporate income tax by 7–10 percent for 15 years in order to allocate budget for making public buildings more earthquake-resistant. Some other prefectural governments relied on interest-free loans to fund program implementation.

Municipal governments have also established special funds for project implementation. One municipality even increased the property tax to ensure sufficient funding. Municipalities that were slated to be merged with surrounding municipalities sought to carry out relatively high-cost reconstruction or seismic retrofitting projects before the merger, using national subsidies available for municipal mergers.

Several municipal governments have used private finance initiatives (PFIs) to fund project implementation. In most cases, these have allowed work to be completed more quickly than it would otherwise have been. With the success of such attempts, municipal governments have studied how to conduct their own fundraising and have consulted with other municipal governments in the same situation. Local banks have backed them up financially, and consulting firms have supported them administratively.

The case of Kushiro suggests the benefits of PFI. Its completion rate for earthquake-resistant school projects remained at 50 percent for a decade, as the city reconstructed old school buildings that were at highly vulnerable to earthquake through the beginning of the 2010s. Since the reconstruction costs were high even with the national subsidies, and projects were time-consuming, the city could not implement several projects at once. In 2012, at the very end of the reconstruction of four schools, the city introduced a special division for project planning and implementation under the municipal BOE with the goal of accelerating future projects.

The special division first allocated additional technical staff capable of handling the projects, and then choose to finance work with the PFI method. The staff visited other BOEs that had introduced PFI and got useful advice for implementation. The city went on to complete the targeted retrofitting projects within three years, achieving an 85.8 percent retrofitting completion rate in 2015 with the completion of the first PFI launches. It is expected to reach a 98 percent completion rate with the second PFI launches in 2016 (the remaining 2 percent includes schools that may be merged).

In meeting these financial challenges, local governments contributed to the overall successful performance of the program.

4.2.3 Collaboration with schools and communities

Throughout the process of implementation, steering committees need to reach consensus with schools and communities. In the municipalities that have experienced powerful or frequent earthquakes in the past, there tend to be few obstacles to consensus, as the community understands the need for and supports school retrofitting. But consensus is harder to achieve in municipalities that have experienced fewer earthquakes. Steering committees cannot simply force projects' implementation in the absence of the community's consensus. Thus some municipalities must decide on the acceptable contents and timing of construction works in light of community's opinion or requests, and under these circumstances the work can take longer than usual.

It should also be mentioned here that although school retrofitting procedures are initiated by local governments, school staff and community residents also play an important role in maintaining school facilities for use as evacuation centers. Schoolmasters, teachers, and staff are responsible for checking facilities and equipment regularly and for reporting the need for repairs to local governments. Teachers periodically update evacuation plans by incorporating the information on reinforced buildings. In addition, teachers prepare and provide newsletters and release articles on their school websites to update parents, children, and residents about the school seismic retrofitting project plans and results.

4.3 Drivers of Success

Local governments faced various challenges and took various countermeasures in implementing the school retrofitting. Table 4.2, which summarizes the results of interviews with local governments, shows that local governments utilized available resources and existing relationship with stakeholders to meet challenges.

As has been noted above, the decision by MEXT to announce municipalities' annual progress in seismic retrofitting/reconstruction has motivated municipalities quite well, particularly in rural areas where initially progress was slow. MEXT periodically analyzes the reasons for slow progress and offers advice to and consults with the municipalities in needs. It has also motivated governors to accelerate work under the program by releasing the comparative rankings of municipalities on its website and through other media, an approach that in addition to speeding up progress has also helped to raise community awareness.

Table 4.2: Challenges faced and measures taken by local governments

Category	Challenge	Countermeasures Taken
Human resources	• Staff shortages	• Allocation of additional staff according to the annual plan • Clear task demarcation among stakeholders • Administrative support by prefectural BOEs
	• Complicated process for procurement / other procedures	• Introduction of special section for program implementation with procurement authority • Allocation of technical staff specializing in architecture • Effective use of consulting firms (e.g., for assistance with private finance initiative procedures) at municipal level
Financial	• Limited municipal budget	• Multiple applications of different types of subsidies; consideration of various ways to secure budget / raise funds (good access to national subsidies prioritized for economically disadvantaged areas was a big help) • Establishment of special funds for project implementation at prefectural and municipal levels • Increase in taxes (e.g., corporate income tax and fixed property tax) to supplement the budget for projects at prefectural and municipal levels • Collaboration with local banks to secure a sufficient budget in the use of PFI schemes

Category	Challenge	Countermeasures Taken
Technical	• Shortage of technical firms in the municipality	• Opening of bidding opportunities for seismic evaluation and construction works beyond prefecture • Effective use of consultation from third parties (academia, private sector, etc.)
	• Difficulty in ensuring consistency in procurement processes over some steps of planning and implementation	• Outsourcing of a series of projects (for seismic retrofit planning and implementation) to one architectural firm
	• Need to complete seismic retrofitting projects in a short period such as during summer vacation	• Use of popular methods recommended by technical institution (JBDPA) to shorten the construction process and make construction works smoother (where recommended materials and specialists trained by the institute were available)
Other	• Low levels of awareness of the need for school retrofitting among communities	• Holding of frequent workshops for awareness raising • Effective use of MEXT annual progress report (e.g., ranking of results by municipalities) • Effective use of school seismic retrofitting progress reports at prefectural and municipal levels to get consensus from residents • Effective use of media for announcing the municipality's seismic retrofitting plans to get public interest in and consensus for the projects • Sharing of information via school newsletters and school websites to get consensus from parents
	• Unexpected decision to merge certain schools	• Flexible response by municipalities—i.e., change in schools' priority for retrofitting, possibly speeding up overall progress

Source: Based on study team's interviews with randomly selected local governors (2016).

Chapter 5
Remaining Challenges

By the end of FY 2015, the Program for Earthquake-Resistant School Buildings had succeeded in making more than 95 percent of public elementary and junior high schools earthquake-resistant. A number of challenges in making schools safer remain, however.

Challenge 1: Make schools safer from multi-hazards. While both the central government and local governments have sought to make schools earthquake-resistant, they have until recently placed less emphasis on preventive measures against multi-hazards. The 2011 Great East Japan Earthquake, however, showed that schools could be earthquake-resistant and still completely vulnerable to tsunami. In 2014, the cabinet secretary issued a plan for developing hazard maps, particularly for floods and water inundation disasters, which schools and local government authorities could use in order to understand their risk and prepare for future hazards.

Challenge 2: Make nonstructural elements of school buildings earthquake-resistant. In spite of prioritizing safety of nonstructural elements in schools buildings, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) found inadequate inspection and remediation measures in place in a 2012 survey on Status of Seismic Resistance of Public School Facilities.[18] Schools and local government authorities are more conscious about ceiling and nonstructural safety generally than in the past, but greater efforts to conduct regular inspections and take necessary measures for all nonstructural elements are needed.

Challenge 3: Improve functionality of schools as evacuation centers. With more than 90 percent of public schools designated as evacuation centers, it is important to ensure their functionality in the event of disaster. Currently, under half (46.8 percent) of schools are equipped with emergency information network devices, and only around one–third (34.2 percent) are equipped with electric generators. As of 2015, less than half of municipalities and 70 percent of prefectures had a school utilization plan in case of emergency.

Challenge 4: Address aging of school buildings. The average age of Japan's school buildings is rising: the percentage of schools older than 25 years of age increased from 21.4 percent in 1994 to 74.6 percent in 2014. Maintaining and renovating these buildings will entail a great deal of work and will need to address various problems that affect the safety of schoolchildren (such as falling exterior walls, window frames, and handrails), among other issues. Following the lead of the Ministry of Land, Infrastructure, Transport and Tourism, MEXT now promotes rehabilitation that extends buildings' life span (MEXT 2014). Under this approach, all parts of the building are removed and completely refurnished using the original post and beam as the structure, which costs 30–40 percent less than conventional reconstruction. If correctly timed—that is, not more than 45 years after the initial construction—this method can lengthen the life of the buildings by 30 years or longer.

18 The survey found that 66.0 percent of schools were inspected, and that of these, under half (48.5 percent) took countermeasures when abnormal conditions were uncovered. The survey also found that only one-third of nonstructural elements that could prove fatal if they fell—such as ceiling materials, lightning apparatuses, and basketball hoops—were inspected.

Challenge 5: Address the impacts of school consolidation. Consolidation or closure of schools, which occurs because of population decline or urbanization, has had a negative impact on the program. Almost 3,000 municipal elementary schools and 600 municipal junior high schools were closed between 2002 and 2014. When a school is targeted for closure or for consolidation with another school, any investments in the school building are postponed in some cases, even when it is found to have insufficient seismic capacity. Thus closures and consolidations have made balancing the safety of schools with cost-efficient investment a major issue.

Challenge 6: Promote seismic retrofitting in private schools. Seismic retrofitting of private schools has lagged behind that of public schools. As of April 2015, more than 15 percent of private school buildings were waiting for school retrofitting or reconstruction. The national subsidy has been available for retrofitting of private school buildings but was considered insufficient in light of private schools' financial difficulties (due to the decreasing number of schoolchildren). MEXT has recently increased available subsidies—including one specifically for reconstruction of private schools and one that covers the prefecture's expenditures on private school retrofitting[19]—and private school retrofitting is expected to make better progress as a result.

19 The national subsidy covers 70 percent of the repayment of interest and principal on prefectural bonds through the local tax allocation system.

Chapter 6
Lesson Learned

Japan's notable achievements under the Program for Earthquake-Resistant School Buildings suggest certain lessons for developing countries seeking to improve the seismic safety of their schools. Lessons on policy development, program design, and program implementation are summarized below.

1. Building on experiences from previous disaster events can provide momentum to accelerate school retrofitting.

- One of the biggest impetuses for developing and promoting school retrofitting is the experience of earthquakes.
  - The 1995 Great Hanshin-Awaji Earthquake triggered the development of the program's comprehensive guidelines, and the program gained momentum after the 2004 Chuetsu Earthquake and the 2008 Sichuan Earthquake in China.
  - Collection and analysis of accurate data on past damages, the implications of this information for building structure and standards, and the disclosure of this information to the public were effective in raising the awareness of program implementers as well as the general public.
  - In Japan, concrete measures were taken to prepare for potential large-scale earthquakes long before the recent major earthquakes. Making schools safe is considered a long-term initiative.

2. Information disclosure is key to raising public awareness and encouraging program implementers.

- The disclosure of information on hazard risk and damage caused by past earthquakes has been the most powerful tool for raising public awareness about the need for seismic retrofitting of schools. An informed public supports local governments' efforts in the program and puts pressure on them to make progress.
- The public disclosure of data on the progress of each local government can be effective in stimulating local leaders and can in turn speed up the seismic retrofitting.

3. The roles and functions of schools in disaster management must be clear to determine the retrofitting and improvements necessary for school facilities.

- In Japan, a school is the core of the community, and many schools are legally designated as evacuation centers. Governments' efforts to retrofit schools and schools' own efforts to prepare for an emergency are prompted by these roles.
- Schools have the responsibility of using the school building properly—that is, for checking facilities and equipment regularly and conducting regular evacuation drills.
- When a school is used as an evacuation center, the disaster management unit of the community works closely with the school. The responsibilities of school headmasters and the community are clearly specified so that the evacuation runs smoothly.

4. Data play a powerful role in the design and the promotion of the seismic retrofitting program.

- The availability and usage of data—on school facilities, program progress, analysis of past earthquake damage, and hazard risks—contributed to the development and promotion of the school retrofitting program.
  - School facility data collected through an annual survey was used as baseline data.
  - Additional surveys on the status of seismic retrofitting provided detailed information on the progress of the program, which served to drive program promotion.
  - Explicit indicators of progress, such as the percentage of local schools that were earthquake-resistant schools, were utilized to secure funding for the program.
  - Qualitative data were utilized to help the national government grasp the difficulties faced by local governments and to take measures during the implementation of the program to address these difficulties.

5. Comprehensive and flexible program development with clear priorities and targets is important.

- The Ministry of Education, Culture, Sports, Science and Technology (MEXT) developed a program with clear priorities and targets, and designed implementation strategies that were feasible from the technical, managerial, and financial points of view. All these contributed to the success of the program.
  - MEXT developed detailed technical documents with various references to achieve the target, and conducted dissemination seminars/training for local governments.
  - MEXT prepared the funding scheme, which was reviewed and upgraded based on the progress at the municipal level.
  - MEXT carried out close monitoring and offered appropriate feedback to ensure the feasibility of the program and to improve it.

6. The advancement of engineering research should serve as a basis of developing a school retrofitting program. The ready availability of engineers to design and implement the program better ensures effective and efficient school seismic retrofitting.

- Retrofitting technology was accumulated and advanced based on past earthquakes and practices in the model area. MEXT policy and strategies were built upon such accumulation of engineering research and knowledge.
  - The Ministry of Land, Infrastructure, Transport and Tourism (MLIT), along with the Building Research Institute, played a central role in establishing building standards.
  - The Japan Building Disaster Prevention Association (JBDPA) played a major role in developing evaluation standards of seismic diagnosis, and in developing an implementation model of seismic diagnosis and retrofitting in the model area. The collaboration of the local government in the model area with engineering experts in JBDPA accelerated the development of retrofitting activities. JBDPA introduced a series of practical manuals and guidelines throughout the activities that were applicable nationwide.

7. Proactive support by the national government that considers the capacity of program implementers is critical to the program's success.

- MEXT provided technical support to local governments in response to their needs.
  - MEXT produced various manuals, reference materials, and case studies that explained procedures in detail with concrete examples.
  - MEXT and MLIT periodically conducted workshops for dissemination of necessary information to local governments.
  - MEXT commissioned professional organizations to conduct technical training for engineers both in the public and private sector.
  - MEXT set up a consultation desk to quickly respond to inquiries from local governments.

8. Combining seismic retrofitting with other facility improvement is cost-efficient.

- In order to achieve the seismic retrofitting by the target year, MEXT focused on seismic retrofitting in facility development and postponed other facility improvement. As a result, some schools—mostly aged buildings—will have to go through further rehabilitation about 10 years after the seismic retrofitting was carried out. This approach is expensive and burdensome to schools.

Annex 2A

Technical Meetings and Evolution of Program Priorities

Studies commissioned by MEXT		Policy
Topic	*Study on promoting earthquake-resistant school facilities*	**Earthquake resistance in structures as the first priority**
Background	Results of the survey on status of earthquake resistance of school facilities conducted by MEXT in May 2002 indicated that the pace of seismic diagnosis or seismic retrofitting was slower than expected. The study was conducted to examine the concrete measures and steps for seismic retrofitting.	
Study items	1) Issues related to seismic retrofit 2) Method of seismic retrofit plans 3) Case study nonstructural elements earthquake-resistant	
Period	October 2002–April 2003	

<table>
<tr><th colspan="2">Studies commissioned by MEXT</th><th>Policy</th></tr>
<tr><td>Topic</td><td>Improvement of school facilities based on the Great East Japan Earthquake experience</td><td rowspan="4">Countermeasures for tsunami, strengthened functions as evacuation centers, and energy saving measures</td></tr>
<tr><td>Background</td><td>The Great East Japan Earthquake raised new issues about the safety of school facilities and their ability to function as evacuation centers. This study urgently examined both the safety and the disaster management function of schools.</td></tr>
<tr><td>Study items</td><td>1) School safety measures (earthquake resistance, tsunami disaster prevention)
2) Necessary functions as evacuation centers
3) Energy-saving measures (responding to decrease in electricity supply due to the earthquake)</td></tr>
<tr><td>Period</td><td>June 2011–July 2011</td></tr>
<tr><td>Topic</td><td>Working group to examine measures to prevent ceiling materials from falling, under survey and study on promotion of earthquake resistance to nonstructural elements of school facilities</td><td rowspan="4">Measures for suspended ceilings as the priority</td></tr>
<tr><td>Background</td><td>The Great East Japan Earthquake caused ceiling materials (nonstructural elements) in gymnasiums and large halls to fall. This study examined how to prevent ceilings from falling and causing potentially fatal injuries.</td></tr>
<tr><td>Study item</td><td>Measures to prevent gymnasium ceiling materials from falling</td></tr>
<tr><td>Period</td><td>May 2012–March 2014</td></tr>
</table>

Studies commissioned by MEXT		**Policy**
Topic	*Special committee to examine measures against deterioration of school buildings*	**Rehabilitation for life-span extension as the next agenda**
Background	A large number of school buildings were built during 1970s and 1980s, and their deterioration is now a serious issue. A special committee was set up to develop a policy on rehabilitation of school facilities and measures to be taken by MEXT and local governments.	
Study items	1) Development of policy for life-span extension of school buildings 2) Development of handbook for rehabilitation to extend life span of school facilities	
Period	April 2012–February 2013	

Studies commissioned by MEXT		Policy
Topic	*Study on promoting earthquake-resistant non-structural elements of school facilities (2014)*	**Earthquake-resistance in nonstructural elements as the urgent issue**
Background	The Great East Japan Earthquake highlighted the importance of making nonstructural elements of school facilities earthquake-resistant. Yet countermeasures to achieve this were lagging. This study was meant to promote this process.	
Study items	1) Basic principle of inspection and measures for nonstructural elements of school facilities 2) Strategy to promote efforts to make non-structural elements earthquake-resistant 3) Collection and provision of case studies	
Period	June 2014–March 2015	

Studies commissioned by MEXT		Policy
Topic	*Review meeting for developing a handbook for re-habilitation to extend life span of school facilities*	**Rehabilitation for life-span extension as the urgent agenda**
Background	"Basic Plan to Prolong the Life of Our Infrastructure" developed by MLIT in November 2013 urged those responsible for public infrastructure to develop a plan for rehabilitation to extend life spans of individual buildings. School facilities account for 40% of all public infrastructure, and local municipal and prefectural authorities responsible for public schools are expected to smoothly develop a long-term improvement plan.	
Study items	1) Development of a handbook 2) Concrete methods of planning for life-span extension 3) Issues related to planning	
Period	October 2014–March 2015	

<table>
<tr><th colspan="2">Studies commissioned by MEXT</th><th>Policy</th></tr>
<tr><td>Topic</td><td>Working group to examine measures to develop disaster-resilient school facilities</td><td rowspan="4">Development of disaster-resilient school facilities</td></tr>
<tr><td>Background</td><td>After the Great East Japan Earthquake, various institutions amended laws, analyzed the damages caused by the earthquake and tsunami, and reviewed the functions of evacuation centers at the time of the disaster. MEXT set up a working group to examine the countermeasures for tsunami disasters and functions of schools as evacuation centers based on the above research results and legal framework. The working group spent one year examining how to reduce disaster risks and strengthen disaster management at school facilities.</td></tr>
<tr><td>Study items</td><td>1) Development of measures to reduce tsunami risks and to strengthen the functions of schools as evacuation centers
2) Development of a report to summarize the results of researches incorporating the legal framework and educational measures such as cooperation with communities, emergency drills, and disaster education</td></tr>
<tr><td>Period</td><td>March 2013–March 2016</td></tr>
</table>

Source: Based on MEXT data.

Annex 2B

School Basic Survey and Public School Facilities Survey

Since 1948, MEXT has conducted an annual school census, the School Basic Survey, targeting all schools and boards of education at the municipal level that are stipulated in the School Education Act.

The School Basic Survey aims at collecting basic information on schools, including (1) the numbers of schools, (2) the number of classrooms (for elementary, junior high, and high schools), (3) the number of departments (for higher education institutions), (4) the number of pupils/students, (5) the number of teachers and staff, (6) the nature of the school facilities, (7) school expenses, and (8) graduates' career records. The procedures and schedule are as follows: (1) MEXT provides the questionnaires to schools in April; (2) by May 1, the schools submit the answers either by mail or website directly to MEXT, or via prefectures/municipalities, depending on the school's function; (3) MEXT gives an initial report in August; and (4) MEXT releases the final report in December. The results are used for discussing education policies and for planning local tax avenues.

The Public School Facilities Survey, which was first administered in 1954, aims at collecting quantitative data related to public school facilities (except higher education institutions) for budget planning and implementation. The survey determines (1) the school facilities area, (2) the actual minimum required area (calculated as the standard size of area per pupil/student multiplied by the total number of pupils/students), and (3) school buildings whose score on the vulnerability assessment is lower than the standard. MEXT conducts this survey in May by mail or via website.

Annex 3A
Seismic Index of Structure *(Is)*

In the *Standard for the Seismic Diagnosis of Existing Reinforced Concrete Buildings* (JBPDA 1990a), the seismic performance index of a building is expressed by *Is* for each story and each direction as

$Is = E0 \times SD \times T.$

E0 is a basic structural index calculated from the product of strength index (*C*), ductility index (*F*), and story index (φ). *C* denotes the lateral strength of the building in terms of shear force coefficient. *F* denotes the ductility index of the building ranging from “more brittle” to “most ductile,” depending on the sectional properties and detailing. φ is a modification to allow for the mode shape of the response along the building height. *SD* and *T* indexes are reduction factors to allow for the disadvantages in the seismic performance of structures. Specifically, the *SD* index accounts for unbalanced distribution of stiffness both in the horizontal plane and along the height of the structure, resulting from irregularity and complexity in the structural configuration; and the *T* index is employed to allow for the deterioration of strength and ductility due to age after construction, fire, and/or uneven settlement of foundation (Okada et al. 2000).

Annex 3B
Prioritization Survey

Table 3B.1: Classification by construction year and number of stories

Classification	Category
I	Building built before 1971 and higher than 3 stories
II	Building built before 1971 and 2 stories; or building built after 1972 and higher than 4 stories
III	Building built before 1971 and 1 story; or building built after 1972 and 3 stories
IV	Building built after 1972 and 2 stories
V	Building built after 1972 and 1 story

Source: MEXT 2003b.

Using the classification shown in table 3B.2, each correction item is evaluated at three ranks, A, B, and C, with A indicating correction to lower the priority and C indicating correction to raise the priority.

Table 3B.2: Classification by correction items

Correction item	Classification	A	B	C
Strength of concrete	Strength test value Design criteria strength	Over 1.25	When neither A nor C	Below 1.0
Aging conditions of main members	Conditions	Both corrosion of reinforcing steel and cracks are evaluation 1[a]	When neither A nor C	Both corrosion of reinforcing steel and cracks are evaluation 3[b]
Plan	Number of spans in beam direction	No single-span structural frame	When neither A nor C	A half or more have single-span structural frame
	Length of spans in girder direction	All of span length is less than 4.5 m	When neither A nor C	A half or more have span length over 6 m
Position of quake-resisting wall	Structural frame with missing wall in lower level	Nil	When neither A nor C	Existing
	Intervals of walls in beam direction and with or without gable walls	Less than 9 m and also with gable walls in both side	When neither A nor C	More than 12 m or no gable walls
Expected seismic intensity[c]		Seismic intensity less than V+	Seismic intensity VI	Seismic intensity more than VI+

Source: Based on MEXT 2003b.

a. Evaluation 1 for cracks = almost nil; evaluation 1 for reinforcing steel = no specific problem.

b. Evaluation 3 for cracks = cracks wider than 1 mm are seen; evaluation 3 for reinforcing steel = outcrop of reinforcing steel or expanded rusting is seen.

c. The Japan Meteorological Agency seismic intensity scale is used. It is a scale of I to VII, with V and VI each divided into “lower” and “upper.”

Finally, the priority level Rp is determined using the flowchart shown in figure 3B.1.

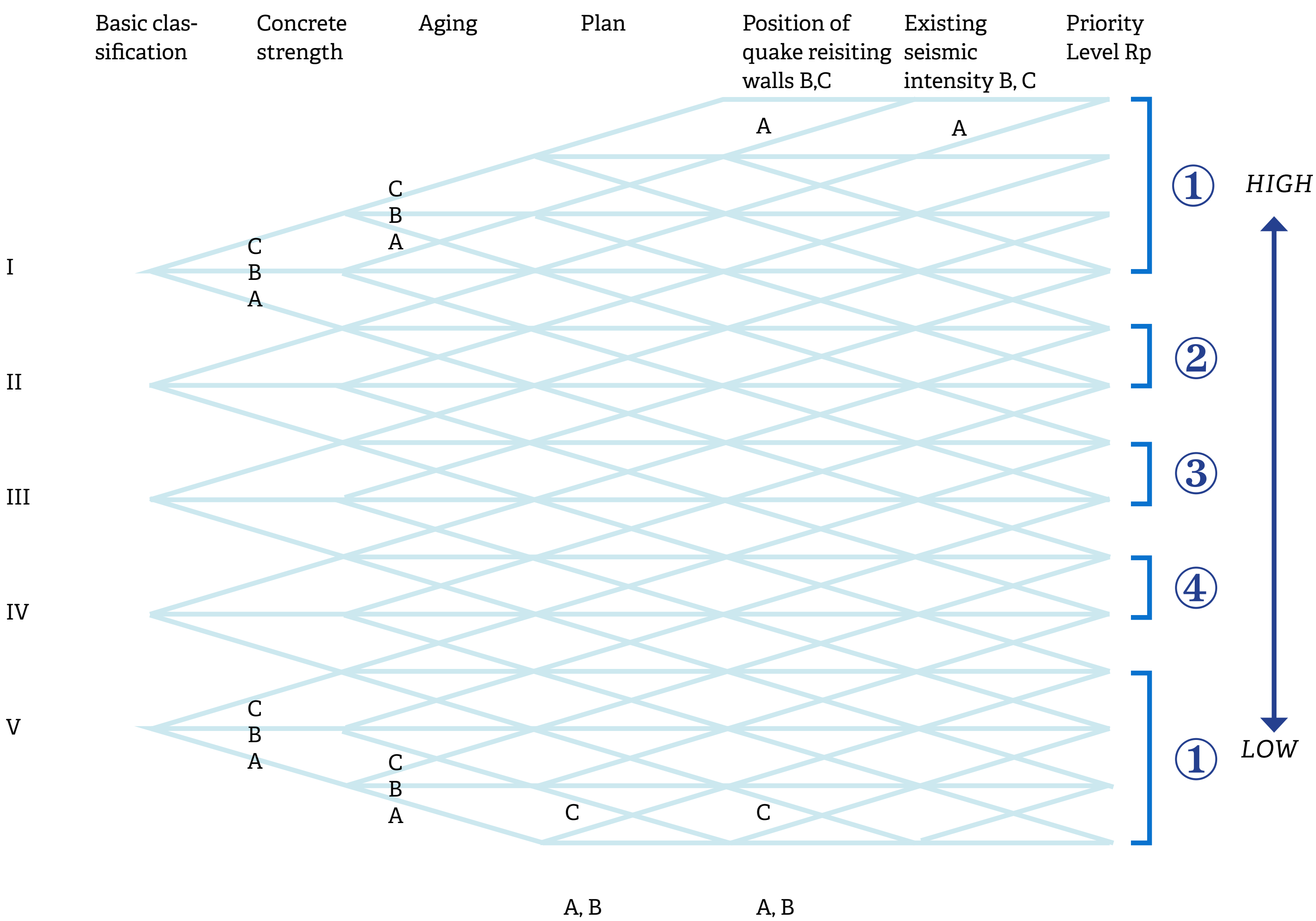


FIGURE 3B.1
Assessment flow in prioritization incorporating correction items

Source: MEXT 2003b.

The prioritization survey for structural steel-framed gymnasiums uses items such as earthquake resistance of steel bracings, corrosion rate of steel members, existence of buckling, weld quality, structural safety, non-structural safety regarding fall prevention, and assumed seismic intensity. Just as for RC, each item is evaluated at three ranks, A, B, and C, with A indicating correction to lower the priority and C indicating correction to raise the priority. The classification is shown in table 3B.3.

Table 3B.3: Classification by correction items for structural steel-framed gymnasiums

Correction item	Classification	A	B	C
Strength of concrete	Strength test value Design criteria strength	Over 1.25	When neither A nor C	Below 1.0
Seismic capacity of structural steel framing brace	I_{SB} value[a]	More than 0.7	More than 0.3 and less than 0.7	Less than 0.3
Corrosion of structural steel	F value[b]	More than 0.8	More than 0.6 and less than 0.8	Less than 0.6
Conditions of buckling	N value[c]	More than 0.7	More than 0.5 and less than 0.7	Less than 0.5
Conditions of welding	M value[d]	1.0	0.7	0.4
Safety of Structure	*Existence of dangers such as* • Lack of members, differences in sectional sizes and number of bolts as compared with the design drawing • Notable deformation and damages other than rust and buckling, sectional fractures, cracks in structural steel regarding the major members of frame and their joints • Partial removal of framing braces on the frame in girder direction	Not recognized	n.a.	Recognized

Correction item	Classification	A	B	C
Safety of falling objects	*Existence of danger such as* • Collapsing of exterior wall surface • Falling by break at joints • Falling of piece of concrete by damages • Falling of finishing material of wall, pendants, ceiling material • Shifting and collapsing supports to floor framing (post)	Not recognized	n.a.	Recognized
Expected seismic intensity[e]	Expected seismic intensity	Seismic intensity less than V+	Seismic intensity VI	Seismic intensity more than VI

Source: Based on MEXT 2003b

Note: n.a. = not applicable.

a. ISB is the earthquake resistance capacity of the steel framing brace, which is calculated by ISB = Cyi × 1.3/AiFesi where Cyi is estimated value of yield layer shear modulus of the steel, Ai is the indicator showing vertical distribution of earthquake layer shear force coefficient based on vibration characteristics of buildings, and Fesi is the indicator to show the shape characteristic of each floor. Calculation method of Ai and Fesi is prescribed in Enforcement Regulations of the Building Standards Law.

b. F value, corrosion of structural steel is calculated by F = 0.5 (fframe + fcolumn base) where fframe is conditions of corrosion on the major members of frame and fcolumn base is conditions of corrosion on the exposed type column base.

c. N value, Conditions of buckling is calculated by N = nlocal × ntotal, where nlocal is the local buckling of major members of frame, and the ntotal is the total buckling of the major members of frame.

d. M value is calculated by M = min (m0, m1, m2, m3, mn), where mn is welding conditions of the welded seams between columns and beams of the major Rahmen frame. The lowest m in the surveyed portion is to be M.

e. The Japan Meteorological Agency seismic intensity scale is used. It is a scale of I to VII, with V and VI each divided into "lower" and "upper."

The value of priority index P is calculated using the following formula:

Priority index P = (Number of level B) + 5 × (Number of level C)

The prioritizing level Sp is determined as shown in table 3B.5.

Table 3B.5: Priority assessment for structural steel-framed gymnasium

Value of priority index P	Priority level Sp
21-35	① HIGH
16-20	②
11-15	③
6-10	④
0-5	⑤ LOW

Source: MEXT 2003b.

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The Global Facility for Disaster Reduction and Recovery (GFDRR) is a global partnership that helps developing countries better understand and reduce their vulnerabilities to natural hazards and adapt to climate change. Working with over 400 local, national, regional, and international partners, GFDRR provides grant financing, technical assistance, training and knowledge sharing activities to mainstream disaster and climate risk management in policies and strategies. Managed by the World Bank, GFDRR is supported by 34 countries and 9 international organizations.

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The World Bank Disaster Risk Management Hub, Tokyo supports developing countries to mainstream DRM in national development planning and investment programs. As part of the Global Facility for Disaster Reduction and Recovery and in coordination with the World Bank Tokyo Office, the DRM Hub provides technical assistance grants and connects Japanese and global DRM expertise and solutions with World Bank teams and government officials. Over 37 countries have benefited from the Hub's technical assistance, knowledge, and capacity building activities. The DRM Hub was established in 2014 through the Japan-World Bank Program for Mainstreaming DRM in Developing Countries – a partnership between Japan's Ministry of Finance and the World Bank.

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