National Disaster Management Agency
The Republic of Indonesia

No.

Urgent Project on Reconstruction of Schools Considering Quake-Resistance and Community based Disaster Risk Management in the Province of West Sumatra in the Republic of Indonesia

Key Requirement for Safe School Construction

AUGUST 2011

JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

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KEY REQUIREMENT FOR SAFE SCHOOL CONSTRUCTION

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1. Introduction

1.1 Background

Table 1.1.1 shows the damage of school buildings caused by the earthquake on 30th September 2009. Nearly half of vocational schools, more than 35 % of senior high schools and junior high schools, and more than 20 % of elementary schools were damaged. These percentages are much higher than the collapse ratio of residential building. In a cram school, twenty children were died because of the earthquake. It is expected that school students would have taken severe damaged if the earthquake had occurred at different time.

18% of schools were collapsed. The number of students in West Sumatra is 895,000. If the earthquake occurred during classes, approximately 150,000 students would have killed.

Table 1.1.1 Damage of School Buildings

School Type	# of School	# of Damaged School	Damage Ratio %	Damaged Classroom		
				Major Damage	Medium Damage	Minor Damage
Pre-school	67	5	7.5	6	-	-
Kindergarten	1,564	29	1.9	29	24	9
Elementary school	3,424	693	20.2	2,004	639	599
Exceptional school	68	23	33.8	21	5	7
Junior High school	524	187	35.7	578	291	368
Senior high school	209	79	37.8	309	186	183
Vocational school	135	62	45.9	202	120	132
Total	**5,991**	**1,078**	**18.0**	**3,149**	**1,265**	**1,298**

Table 1.1.2 Damage of Houses of Padang City

	Heavy Damage (RB)	Middle Damage (RS)	Light Damage (RR)	Total Damaged (TD)	Total House Unit
Number	9,635	16,544	23,314	49,493	175,409
Ratio	5.5%	9.4%	13.3%	28%	

Source: Andalas Univ.

1.2 Objectives

As the reason that the collapse ratio of schools is much higher, it is considered that building age of school is old and the building does not have enough earthquake resistantance. Community pointed out that there are frequent cozy relationship between administration officials and school building constructor and that the constructor does not construct school buildings, using necessary cost actually. There is possibility that many students are damaged by future earthquake if it occurs in specific time which causes more damages. In the current project, the goal is to promote safer construction of school

buildings in the Republic of Indonesia. To achieve the goal, not only schools in the affected area are rebuilt but also guidelines, construction manuals, and other necessary things are proposed to promote safer construction of school buildings in the country and consultation with related organizations is done so that they refer the proposed documents for safer construction.

2. Speculation of Problems: The Current Situation and Problems on School Construction

2.1 Current situation of construction of community participatory school construction

(1) Current situation of safer construction of school buildings through community participation by AusAID

AusAID has many achievements of community participatory school construction in Indonesia. The purposes of community participatory school construction are to raise organization/committee which can manage school in the process of the construction, to encourage community to feel familar, to enhance ability of self management through distribute budget to the organization/committee, and to achive sustainability of operation and maintainance of schools after the construction.

In the framwork, construction consultant of Austraria manage projects as managing consultant. Under this, school management committee which consist of local leader, school principal and teachers are established for construction of school buildings. The committee select local construction company and make employment contract with the company to start the construction of school buildings. Necessary cost is give to the committee from AusAID and the committee manage the construction of school and operation and maintainance after the construction. To achieve it, AusAID provide the committee with the enough training.

(2) Workers of construction companies

Construction companies recruit local people as workers in Indonesia as well as the project by AusAID. Even in the reconstruction after the earthquake of 2009, local people was employed as workes for construction of school buildings and houses in the affected areas. In many cases, people who do not have knowledge of construction are employed and woked without suffcient training or instruction from taskmaster. This is one of reasons that construction quality is not kept. Utilization of local human resource in the process of reconstruction is important in the point of contribution to local economy. But practicable training to acquire construciont knowledge is necessary.

(3) Differences between community participatory school construction and school construction in JICA method

Under JICA's scheme, implementation scheme by AusAID is difficult to be accepted and impossible to be applied. Table 2.1.1 shows the differences between community participatory school construction and school construction in JICA method, and new approaches adopted in the current project

Table 2.1.1 Type of school construction and its characteristics

Type of school construction	Overview	Advantage	Disadvantage
Community participation type	AusAID is implementing this type. Necessary cost is transferred to school steering committee which consists of local community and leader. Local managing consultant designs school building and it is construct by local construction company selected by the committee.	Cost is relatively low. Skills, awareness, and knowledge of construction are cultivated.	There is the possibility that fund is used for unauthorized purposes. Construction of school building might be unskilled. Quake resistance may not be ensured.
Conventional JICA type	Cost is covered by JICA. Consultant in Japan designs school building and local constructors construct school. Construction is managed by consultant in Japan.	Design is ensured. A certain level of quake resistance is ensured.	Cost is relatively high. Construction duration is long. Few knowledge and awareness are remained. JICA does not give warranty on the quality of school building.
Innovative community participation type (implemented in the current project)	JICA (or government or donnor) covers cost. Japanese or specilized consultant design school building and local constructor construct it. Japanese or specilized consultant manage construction. Local community around school give needs on design of school building and monitor construction in order to improve school building. School building is used for a center for disaster management. Disaster education is conducted.	Quality of design is ensured. A certain level of quake resistance is ensured. Community can get knowledge and awareness of construction and disaster management. School is utilized for disaster management activities and center for it. Maintainance of school building is improved. Knowledge of disaster management and quake resistant building are remained through carpenter training and transmission of knowledge of earthquake resistant building to local community.	Cost is relatively high. Construction duration is long because training and education are necessary. JICA does not give warranty on the quality of school building. Instruction by local government is necessary and cooperation by many organizations/institutes are necessary. Warranty of school building is necessary.

2.2 Awareness on safer construction of school buildings with earthquake resistance

(1) Purpose of survey

To understand awareness on construction of school buildings with earthquake resistance, needs assessment survey was implemented when the survey was started. In the survey, interview related to response and awareness on the earthquake in 2009 and problems and lessons were acquired. People's awareness on how they should prepare for future disasters is also checked. According to these results, implementation concept of the current activity was established.

(2) Survey method

Before starting community activities, focus group discussion and interview survey was conducted. The participants filled out survey form with their own opinions, the forms were collected by JICA Study Team, and the team count and analyzed the forms. The targets of the

survey were eleven schools and their community where community based disaster management activities was planed to conducted and 5-20 people in each place were collected for the survey.

(3) Survey results

The following are main opinion on buildings with earthquake resistance through focus group discussion. When the question related to the lessons of the earthquake was asked, forty five people out of hundred pointed out importance of buildings with earthquake resistance. This opinion is much more than other lessons. Table 2.2.1 is the results of the lessons of the earthquake.

- Majorities of respondents, 45 samples out of 116 samples answered the necessity of earthquake resistance construction. They have notions that existing way of construction cannot sustain from the next earthquake. Not only the necessity of earthquake resistant construction, but also, necessities of observing building code, knowing earthquake resistant buildings, providing knowledge on earthquake resistant buildings, knowing method of inexpensive earthquake resistant construction, constructing buildings by skilled construction workers were raised.
- After the 30th of September earthquake, the necessity of earthquake resistant buildings or buildings which have slight impacts for human has become prevalent. In the 30th of September earthquake, wooden houses had less damage, compared with brick houses. Thus, the fact has created general perceptions that wooden houses are stronger. In this way, perceptions of people have changed and people started to use woods at the upper side of the houses. However, it is necessary to disseminate correct knowledge on buildings to the general public.
- There are lots of contractors which construct buildings by their own ways at present. There are many people who insist the necessity of acquiring earthquake resistant technology.
- There are often cozy relationship between public officials and contractors of school in constructing schools, so schools are not necessarily constructed by spending necessary costs. Thus, many people want foreign donors to construct schools.

Table 2.2.1 Lessons Learned by Earthquake in September 2009

#	Lessons Learned	Countes
1	**Necessity of Quake Resistant Construction**	**45**
2	**Preparation of Emergency Kit Bags (water, foods, medicines)**	**13**
3	**General Preparedness**	**8**
3	**Trauma Care**	**8**
5	**Cooperation in the community**	**7**
6	**Securing safe evacuation place & shelters**	**5**
7	**Mental preparation, not to be panic**	**4**
7	**Evacuation Drill and First Aid Trainings**	**4**
9	**Basic knowledge on Disasters**	**3**
9	**Awareness Raising**	**3**
9	**Knowledge on emergency reactions**	**3**
12	**Coordination between communities and public authorities**	**2**
12	**Necessity of Disaster Education**	**2**
12	**Preparation to flood and landslides**	**2**
12	**Contermeasures of Infrastructures**	**1**
16	**Preparation for landslide**	**1**
16	**Preparation for Tsunami**	**1**
16	**Knowledge sharing of other disaster affected areas**	**1**
16	**External Assistance**	**1**
16	**Cannot do anything**	**1**
	Total	**115**

2.3 Stakeholders on school construction

To collect opinions on construction of school buildings, the following organizations were visited.

- Ministry of Education, Education Department of Wes Sumatra, Education Department of Padang City, Education Department of Padang Pariaman Regency, and teachers
- Ministry of Public Works (PU), Public Works of West Sumatra province, Construction Association of West Sumatra and Padang
- National Board for Disaster Management, Board for Disaster Management of West Sumatra Province, Board for Disaster Management of Padang City, and Board for Disaster Management of Padang Pariaman District
- JICA expert (Mr. Kamemura)

2.4 Problems on construction of earthquake resistant school

To construct schools with earthquake resistance, there are two main problems to be solved as below.

(1) The guidelines of construction of school buildings for Ministry of Education that quake-resistance standards in the building code regulations are not reflected in

Ministry of Public Works has stipulated the standards of structural design of each zone, following the article 45 of the building code regulations. However, the guidelines developed by the Ministry of Education for construction of school buildings is mentioning the standards of size of classroom, types of facilities, and others but does not mention the standards of building structure. The guidelines also include standard design for construction of school buildings but standard design can not keep enough earthquake resistance of schools in Padang Pariaman,

where earthquake hazard is high. In other areas, it is also difficult to keep earthquake resistance.

(2) Building quality which is not ensured in construction of school buildings

In construction process, building quality is not ensured. As mentioned before, workers employed by construction company do not take enough training. Even though they use same construction materials, it is possible to ensure earthquake resistance of school building, following several points to be kept. But school building with earthquake resistance is not constructed because these points are not kept. These points can be applied to general residence and other buildings.

Figure 2.4.1 shows Problems of construction of earthquake resistant school

Table 2.4.1 shows issues of construction of school buildings

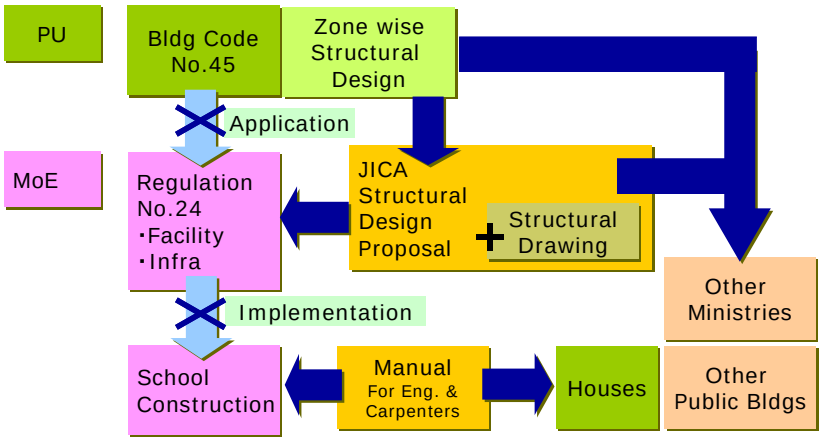

Figure 2.4.1 Problems of construction of earthquake resistant school

Table 2.4.1 Summary of Issues

Institutions		Items	Status and issues
Ministry of Public Works (PU)	Central government	Laws & building standard	Law is defined in No35, year 2005、decree No.29/PRT/M/2006（SNI）、decree No45/PRT/M/2006. Building code is described in SNI1726(2002). Regional coefficient with six levels is defined. Padang is located in highest level zone of level six.
		Building permission	It is conducted by provincial or district government, not by branch office of PU.
		Manual for construction	JICA's experts' team had issued a booklet for Key Requirement.
		Educational materials	Teddy Boen developped educational material for Key Requirement for house builders in 2008. JICA's experts team for building policy improved this to be understandable for the public. Promotion activities of key requirement were conducted for building authorities, private housing sectors, and citizens in Kechamatan level in three pilot provinces.
		Capacity of staffs	Few staffs graduated from civil engineering department in university. Most of the staffs graduated from architect

Institutions		Items	Status and issues
			department. Staffs can design but few understand structural engineering. Knowledge on aseismic building is not enough.
		Training of staffs	No training on aseismic building is conducted except for the one by JICA expert team.
		Certification system	There is no certification system for foreman and builders. There is no responsible department in government. Certification of architects, IAI, is not functioning well. Clinic consultansi headed by Prof Febrin had conducted training for house builders during 2007 to 2008 and issued certificate. However, the training discontinued. Construction directorate of PU is responsible for certification of architects and engineers. Association of structural engineers (HAKI) issues certification of structural engineers. Technical skills of builders can be certified as national license by uniform standard. Certification can be done by practice based examination at provincial office of PU.
		Inspection & monitoring	Iron bars stamped as "10mm diameter" is widely sold in market, however, its diameter is actually only 8mm. Inspection and monitoring system for construction material by PU is not sufficient.
		Budget	Most of the budget for the realization of safe school construction is used for staffs' salary. It is possible to realize safe school construction if stakeholders for the discussion agrees.
	Provincial office	Law and regulation	Provincial law related to earthquake resistance was made and was during application. Area coefficient is revised and building code on earthquake resistance is raised.
		Inspection	Branch office of PU inspects construction work of school for three times (initial, middle, final). However, schools constructed by donors are not subject to inspection. According to the law, management fee should be included in the construction cost and PU should monitor construction works in case of public building construction. However, management cost is reserved in some projects only. In case there is no reserve fund for monitoring, PU can inspect free of charge.
		Training	Training on aseismic building is underway by JICA project.
		Certification system	Director of PU in West Sumatra says GAPENSI is suitable to conduct training for engineers and builders.
		Institutions	PU has branch offices in provinces. Though there are no PU branches in regency and in district, however, there is a section for building permission in permission service division (KPPT) in urban planning department, in which engineers from PU are assigned.
Building permission in local government	Province		Building permission is the responsibility of regency and district, not of province.
	Regency and district	Building peermission	Urban planning department or building department in regency or district government has building permission office. Ministry of interior had ordered to establish KPPT in all local government, however, it is still in transient stage and the situation differs from place to place. Urban planning department (tataluan) in Padang district government has a section for building permission. KPPT in Padang Pariaman regency uniformly accepts building permission including commercial permission.

Institutions		Items	Status and issues
			In Padang Pariaman regency, request for house building permission was accepted in Kechamatan and KPPT issued permission. However, Kechamatan can issue permission recently except for houses higher than two stories. Department of education in local government submit documents of request for building permission to KPPT or department of construction, and department of construction issues permission. No problem arises even if different institution works for permission and inspection.
		Certification	Not issued in Padan Paliaman. Some regencies issue certification for builders.
Construction workers association (GAPENSI)		Registration of builders	All construction companies are registered to the associon of construction companies. Annual fee for the registration varies for six levels according to the size of company. (Rp 1,150,000～8,600,000)
		Staffs	Member from registered company works as staffs for four year term.
		Tender system	Committee is established for tender process to ensure the fair procurement. Committee members select a company
		On site inspection	There is an association (INKINDO) specialized for planning and inspection, that undertakes inspection works for PU. Details of undertaking are not clear. According to the hearing from PU, private sectors do not work for inspection.
		Bribe	Bribes of 10-15 % are requested by officials to execute public works. Local residents also request bribes and intervene construction works if bribe is not paid. Bribe is a big problem to downgrade construction quality.
		Explanatory documents	Not issued by association.
		Manual	Not issued by association.
		Training material	There are training materials for engineers and builders.
		Training	Training for engineers and builders are given twice a year. About 30 to 40 participants receive training. It is easier to hold training from January to March. However, no training on aseismic buildings was given. JICA's training was useful.
		Certification	Trainees who completed training by association are given certification. Issued certification is attached for bidding documents.
		Material cost	Material costs are more expensive in Jakarta.
Education sector	Ministry of education	Construction guideline	The ministry is responsible to expand guideline to nation wide. Ministry intends to observe the good practice in West Sumatra province firstly, then consider its nation wide application. Budget allocation to construct aseismic buildings is the primary problem.
	Department of education in province	Construction guideline	Provincial government basically coordinate works between national and local government. Therefore, provincial government is not involved in administrative procedures to legalize school construction guideline. However, provincial government works to disseminate guideline in West Sumatra province.
		Disaster education	It is obligated that school conduct disaster education twice a month. Any programs are permitted to be done, for example,

Institutions		Items	Status and issues
			practical training like evacuation training or first aid, education in class room using newspaper, and others. Education materials are not decided. Textbook developed in the current project was authorized by the province. In some schools, they are using the textbook.
	Department of education in district	Budget	Construction of aseismic buildings costs 60% more than conventional construction. However, budget from ministry of education is not enough. It is necessary to work with ministry of finance to increase the budget.
		Construction guideline	Ministry of education does not publish guideline for earthquake resistant school building. However, ministry of public works publishes guideline for earthquake resistant buildings for public buildings.
		Design	Contractor designs buildings when they are hired. It is not known who designs school building when community participatory school construction is conducted.
		Contractor	Contractor is selected by bidding when necessary.
		Builders	School committee sometimes hires builders directly to build school. For this reason, it is effective to enlist skilled builders.
		Maintenance	Expenses for school maintenance is requested by school committee and school master to the department of education and thus allocated.
	School teachers	Disaster education	Department of education in West Sumatra province has been developing a curriculum for disaster education for last three years. However, teachers in schools had not conducted disaster education.
		Teachers' capacity of disaster education	Teachers are not trained for disaster education. Opportunity of training for teachers to conduct disaster education is need.
	School committee	Knowledge of aseismic building	Committee members do not have knowledge for key requirement of aseismic building. It is effective to have a capacity to monitor construction works on site.
Disaster management board	BNPB	Community disaster management Evacuation plan	BNPB understand necessity of disaster education, designation of evacuation places, and evacuation map. BNPB plays the role to promote disaster management in province, regency, and district level.
	West Sumatra provincial board	Community disaster management	Officer wishes to conduct training of disaster education and handling of disaster prevention equipments for residents. They do not have concrete plan in 2010 because the board was established March 2010. But they had intention to conduct disaster education. In 2011, they started coordination for disaster management activities in regency and district level.
		Evacuation plan	Officer wishes to designate evacuation area and to deploy equipments for disaster prevention. They are making lists of high building for use of evacuation building with cooperation of PU.
		Designation of evacuation area	Officer agrees to designate earthquake resistant school building as disaster management base. They are making the list of multistory building for use of evacuation building with PU. They plan to designate the buildings as evacuation building through checking building condition if building can provide evacuation function.

Institutions		Items	Status and issues
	Padang Pariaman regency board	Community disaster management	There is no disaster education plan for residents, since the board was established in February 2010. The plan will be formulated in near future. In 2011, formulation of community disaster management organization which consists of student's parents based on school area is conducted.
	Padang City board	Community disaster management	City board was established in January 2009, prior to the earthquake. Four cycles of training was conducted for four Kechamatans, gathering 200 to 400 community leaders. Community leaders were responsible to convey same training to each community at the end of everyday's program. KOGAMI conducted training in Padang and West Sumatra province. The program is to be continued in other eleven Kechamatans in Padang. TV program is also produced to explain district government's role on disaster management and to raise awareness among citizens. In 2011, cooperating with NGO, the board designate route and area for evacuation and made and distributed evacuation map. The board set sign in the town and at the main building to show the route and map for evacuation.
Residents		Knowledge of aseismic building	Many residents are affected by the earthquake and their houses are damaged. For this reason, the primary lesson from the earthquake is to ensure the seismic safety of buildings. Many residents attended workshop wish to know how to build strong houses against earthquake. Thus it is necessary to convey knowledge to construct aseismic building. Trainings on Tsunami was given by KOGAMI and etc since 2005.

3. Directions: Approaches toward Promotion of Safe School Construction

3.1 Enforcement policy for promoting safer construction of school buildings with earthquake resistance

(1) Development of guidelines of earthquake resistance building for the Ministry of Education to be applied to construction of school buildings

Based on the earthquake hazard map, guidelines are developed for earthquake resistant buildings in each zone. Standard design is also provided in the guidelines and it shows sizes of column, reinforcing bars, and others clearly. The Ministry of Education aims to apply the guidelines to all cases of construction of school buildings in the future and to more cases of rebuilding of schools in West Sumatra.

(2) Development of construction manuals to ensure building quality

Construction manuals including points to be taken heed in the each step of construction are developed. Based on the manuals, the Ministry of Public Works is expected to provide training to engineers, masters, and workers of construction companies in order to enhance their construction skills and to ensure construction quality.

3.2 Results of consultations with different stakeholders

As for the strategy to promote quake resistant school buildings, separate consultations with Ministry of Education, Ministry of Public Works, National Board for Disaster Management, West Sumatra Province, Padang City, Padang Pariaman Regency, Department of Public Works, Department of Disaster Management, and other were conducted. The following are the consultation results.

(1) Ministry of Education

Building code was established in the country. As for the schools and public buildings which are under the Ministry of Education, the ministry is managing their construction. Generally, public buildings which are larger than a certain size is examined by the Ministry of Public Works and other ministry except the Ministry of Education entrusts the examination of buildings to the Ministry of Public Works. But the Ministry of Education has managed building construction by themselves has not permit the Ministry of Public Works to get involved in. Therefore, the building code has not been applied to the buildings under the Ministry of Education. Consultation with the Ministry of Education has been conducted doggedly through reporting progress to the vice minister in each assignment. The biggest problem for the ministry is increase of the budget. The project team explained that the total of construction cost in each zone is not increased extremely, compared to the current costs. In other words, there is a zone where construction cost is decreased. Even in a zone where the cost is increased, the rate is around 13 %. Currently, the ministry has the direction that they emphasize the quality of

education like computer education and other education. The budget is also followed by this direction. It means that it is not easy to get the budget for earthquake resistant school building.

There is the handbook for school construction published by the Ministry of Education. The handbook mentions the criteria of necessary functions, size of classroom, and other and does not include the criteria of quake resistant building. Therefore, development of the guidelines and the standard design including the criteria of quake resistant building and the construction cost based on the criteria was decided to be examined.

When these materials were completed, the explanation on the guidelines and the standard design was given to the ministry. The vice minister give the explanation to the minister. To apply the guidelines, the ministry planed to promote stakeholders.

Because it takes long time for this procedure and actual acquiring budget, promotion to stakeholders from the JICA project team and JICA office is necessary.

For example, when schools are rebuild or constructed by the West Sumatra Province, it is necessary to monitor school construction/rebuilding based on the guidelines, using the budged increase for the construction. It is also necessary to monitor that donors require to follow the guidelines.

(2) Ministry of Public Works

The article 45 of the building code regulation shows the criteria of quake resistance. It means to ensure quake resistance if it is kept. There are any inadequacies in the regulation and the problems is to keep the regulation. The ministry of Education has not have relationship with the Ministry of Public Works. Therefore, the Ministry of Public Works recognizes difficulty to encourage the Ministry of Education.

JICA Project Team thinks it is necessary that the both ministries have discussion together. It is also important to discuss, understanding the status after the earthquake in West Sumatra Province. Therefore, the workshop was held in August 2010 as the place for discussion, gathering central government, and the education department, the department of public works, and the department of disaster management of West Sumatra Province. The ministry of Public works was absent in the workshop.

(3) National Board for Disaster Management

National Board for Disaster Management is not central player of school construction. It does not have different views about ensuring quake resistance of school building and it is supporter of this issue. The budget of reconstruction of school building would be distributed to schools of West Sumatra Province through the Ministry of Education and the authority could not do anything on this issue.

(4) The education department of West Sumatra Province, Padang City, and Padang Pariaman District

The education departments of West Sumatra Province, Padang City, and Padang Pariaman District have the role to apply the budget to the national government and they agreed to quake-resistant school construction.

The previous president of the department of Padang Pariaman District and the current president of the department of West Sumatra are promoting quake-resistant school construction actively. They showed acknowledgement on development of the guidelines by JICA and activities to promote safer school construction and are suggesting the provincial president to apply the guidelines in West Sumatra Province in the future.

Two model schools have been constructed and the president of the department of education of Padang City checked the schools. He understood the bigger size of columns and beams are used, compared to usual school building. Through the checking, his understanding on quake-resistant school construction was promoted.

The following is the acknowledgement mentioned above.

We really appreciate JICA's efforts in strengthening our education side both by building earthquake safer school building and preparing construction guideline. We are from provincial education office is on process of proposing your construction guideline to our Governor. I have assigned my staff to be in charge of it. After getting approval from governor, we will send instruction letters to each city and district in West Sumatera"

(5) The department of public works of West Sumatra Province

West Sumatra Province made the regulation of the province to enhance the zone coefficient (Annex 1). The procedure is being done to make it legitimized. Thus, the province is eager to ensure quake resistance of school buildings.

The construction manual developed by JICA Project Team can be applied to any types of building. Therefore, it was decided that the manual was attached as a part of the tender document of the Ministry of Public Works and the constructors were instructed to apply the manual when the constructed.

In addition, the ministry is planning to provide the training based on the manual because it is possible to ensure quake resistance even if same materials are used for construction.

It is expected that JICA conducts monitoring and support training in the future.

(6) Board for Disaster Management of West Sumatra Province

The president was from the Ministry of Public Works and cooperated to make the province regulation with the department of public works of West Sumatra. He feels necessity of quake-resistant school construction. He is also responsible to decide use of remained reconstruction budget and distribution of reconstruction budget to increased budget for construction can be possible.

It is necessary to encourage him continuously for use of the reconstruction budget and others.

(7) AusAID

AusAID has many experiences and achievements of school construction and JICA Project Team updated and transferred information of the team regularly during the project. The team has explained the school construction guidelines and the construction manual to AusAID. If the guidelines become the standard of the Ministry of Edcucation, AusAID hopes to apply it.

The tendency of AusAID works is to emphasize the number of construction rather than quality of construction.

3.3 Consultations through workshop and other activities

To realize earthquake resistant school construction, stakeholders in the central government came to West Sumatra and consulted together with stakeholders in Sumatra Province, Padang City, and Padang Pariaman District in August 2010. In the first anniversary memorial event on 30th September 2010, the international workshop was held and promotion of quake resistant school construction was conducted at the presence of provincial governor.

(1) Workshop consultation and agreement

To realize quake resistant school construction, the workshop was held on 26th August 2011. In the workshop, the National Board for Disaster Management, the vice minister of the Ministry of Education, the vice president of West Sumatra Province, the pubic works department and education department of the province, district, city, and others consulted and gained basic agreement. The Table 3.3.1 is the workshop program.

Table 3.3.1 The program of the workshop on quake-resistant school construction

Theme	Stakeholder	Content	Name
Policy speech on safer school	Director of National Board for Disaster Management	National Board for Disaster Management's Concept of safer school	Ms.Maria
	The vice president of Ministry of Education	Concept and problem on safer school construction which the Ministry of Education have	Mr. Bambang Indriyanto
	The vice president of West Sumatra Province	West Sumatra provice's concept	Mr.Muslim Kasim
Presentation	JICA	Progress reporting of JICA Project	Mr. Chiaki Kobayashi
	JICA Project Team	Problems on quake-resistant school construction	Mr. Yoshitaka Yamazaki
		Concept and key points on the manual and guidelines of school construction	Mr. Toshiyuki Yamamoto
Presentation	JICA JICA Project Team	Promotion strategy of safer school: Plan and schedule	Mr. Chiaki Kobayashi Ms. Tomoko Shaw
Discussion	All	Facilitators to promote quake-resistant school	Ms. Tomoko Shaw
Field trip	All	Presenter	Mr. Toshiyuki Yamamoto

Based on the presentations and discussions in the workshop, the following are agreed and signed by stakeholders as the meeting minutes. The contents of the meeting minutes are shown as below.

1. It was agreed that it is necessary to decide the criteria of structure of school building. Increased cost is shared by the Nation, Province, District and City.
2. Monitoring by community is conducted for quake-resistant school construction.
3. The criteria of quake resistance are decided based on the earthquake zoning by SNI.
4. Department of disaster management plays the role to develop the technical guidelines to be applied in the province, district and city through adjusting and consulting with the National Board for Disaster Management, the president of the province, and other related organizations.
5. As for the guidelines of aseismic buildings, only one criteria should be approved. The school construction manuals which were developed by JICA project team is changed in the aspect of their format and become the technical guidelines on school construction in the province regulations.
6. The consensus of necessity of specified quake resistant structural standard for school buildings was obtained, however, increased cost is a sensitive matter and it should be shared among stakeholders, namely central government, provincial governments and local governments.
7. To construct quake-resistant schools, monitoring by communities should take into consideration.
8. Standards for quake resistant building should be prepared based on seismic zoning according to SNI.
9. BPBD is responsible for preparing technical guideline to be applied at provincial, city and district level by coordinating with BNPB, Governor, and relevant offices.
10. There should be one authorized and standard guideline of quake-resistant buildings. “Key Requirements for Quake-Resistance Design for School Building” which JICA Project Team has produced, should be converted to “Technical Guideline” format to be enacted as Governor’s Regulation of West Sumatra Province about School Buildings.

The following are photos during field trip at school construction sit.

Photo 1. Field trip at school construction site. (left: The president of the department of education in West Sumatra Province and the vice president of the Ministry of Education, and right: the vice mayor of Padang City, specialists, and others)

MINUTES OF MEETINGS
ON
LEGALIZATION
FOR
URGENT PROJECT ON RECONSTRUCTION OF SCHOOLS CONSIDERING QUAKE-RESISTANCE AND COMMUNITY BASED DISASTER RISK MANAGEMENT IN THE PROVINCE OF WEST SUMATRA IN THE REPUBLIC OF INDONESIA

In response to request from the Government of Indonesia (hereinafter referred to as the "GOI"), the Japan International Cooperation Agency (hereinafter referred to as "JICA") has been conducting the Urgent Project on Reconstruction of Schools Considering Quake-Resistance and Community Based Disaster Risk Management in the Province of West Sumatra (hereinafter referred to as "the Project") in the Republic of Indonesia (hereinafter referred to as "Indonesia")
As the outputs of Component 3 in the Project, "Key Requirements for Quake-Resistance Design for School Building" and "Manual for Quake-Resistance Design for School Building" have been produced. On 26th of August, 2010, a workshop was conducted to discuss on legalization of these two documents among the related officials (see the attachment 1).
In the meeting, participants have confirmed the following items described in the attached sheets.

Mr. Chiaki Kobayashi
Leader
3rd Preparation Mission for Rehabilitation of West Sumatra
Japan International Cooperation Agency

Mr. Bambang Indriyanto
Secretary of General Directorate of Primary and Secondary Education Management

Ms. Drg. Maria Sidang Doki, M.Kes
Director of Damage Assessment
National Disaster Management Agency (BNPB)

Mr. Sugeng Sentosa
Building and Infrastructure Technical Support Team for Rehabilitation and Reconstruction of West Sumatra Province
TPT (BNPB)

Mr. Ir.Firman Dalil
Head of Building and Environment Management
West Sumatera Provincial Public Woks

Mr. H. Burhasman Bur, MM
Department Head
Provincial Education Office

Mr. Ir. H. Harmensyah, Dipl.SE.MM
Head of
Regional Disaster Management Agency of
West Sumatra Provincial Government

Mr. Syamsulrizal, MM
Department Head District Education Office of Padang Pariaman District

1. The consensus of necessity of specified quake resistant structural standard for school buildings was obtained, however, increased cost is a sensitive matter and it should be shared among stakeholders, namely central government, provincial governments and local governments.
2. To construct quake-resistant schools, monitoring by communities should take into consideration.
3. Standards for quake resistant building should be prepared based on seismic zoning according to SNI.
4. BPBD is responsible for preparing technical guideline to be applied at provincial, city and district level by coordinating with BNPB, Governor, and relevant offices.
5. There should be one authorized and standard guideline of quake-resistant buildings. "Key Requirements for Quake-Resistance Design for School Building" which JICA Project Team has produced, should be converted to "Technical Guideline" format to be enacted as Governor's Regulation of West Sumatra Province about School Buildings.

Figure 3.3.2 Meeting minutes on agreed contents in the workshop

Separate from this minutes, different meeting minutes on the guidelines for future school construction was agreed among the Ministry of Education, JICA, and JICA Project Team. The agreed contents are shown as below.

■ Contents agreed by the Ministry of National Education after the workshop

1. Based on the discussion through the captioned project, and Work-shop held on 26th August 2010, Ministry of National Education (hereinafter referred to as "MoNE") and Japan International Cooperation Agency (referred to as "JICA") has a consensus of importance of make up Quake-resistance school building standards so that to avoid huge damage by the earthquake disaster in future to the educational national assets and human resources.
2. And also, the both parties confirmed that Seismic zoning system in Indonesia is updating rapidly by seriously concerned about the recent disaster situation, however, the present MoNE's school building structural standards show in "Perunjuk Teknis" is not conforming to the new seismic standards stipulated by SNI.
3. In this regards, both MoNE and JICA came to have same consideration about the necessity of taking action for improvement of MoNE's guideline.
4. Upon etting mutual consensus, as an initial administrative procedure, MoNE expressed to try to get internal consensus in the Ministry about make-up new standards conforming to quake-resistance design, and after, according to the MoNE's principals, JICA Team will cooperate and start preparing the draft of new standards jointly with Technical Team of MoNE.
5. Tentatively, the target schedules ofprocess discussed as follows;
   (1) MoNE's internal administrative procedure will be completed up to the end of October 2010 and result will be informed to JICA office by letter.
   (2) Draft of New guideline will be completed up to end of December 2010.

(3) Authorization process and issue guideline namely "Perunjuk Teknis 2011" will be completed up to May 2011.

MEETING MEMORANDUM
ON
PROCESS OF MAKE-UP QUAKE RESISTANCE SCHOOL BUILDING STANDARD

Name of the Project
■ URGENT PROJECT ON RECONSTRUCTION OF SCHOOLS CONSIDERING QUAKE-RESISTANCE AND COMMUNITY BASED DISASTER RISK MANAGEMENT IN THE PROVINCE OF WEST SUMATRA IN THE REPUBLIC OF INDONESIA

1. Based on the discussion thorough the captioned project, and Work-shop held on 26th August 2010, Ministry of National Education (hereinafter referred to as "MoNE") and Japan International Cooperation Agency (referred to as "JICA") has a consensus of importance of make up Quake-resistance school building standards so that to avoid huge damage by the earthquake disaster in future to the educational national assets and human resources.

2. And also, the both parties confirmed that Seismic zoning system in Indonesia is updating rapidly by seriously concerned about the recent disaster situation, however, the present MoNE's school building structural standards shown in "Perunjuk Teknis" is not conforming to the new seismic standards stipulated by SNI.

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   (2) Draft of New guideline will be completed up to end of December 2010.
   (3) Authorization process and issue guideline namely "Perunjuk Teknis 2011" will be completed up to May 2011.

Mr. Bambang Indriyanto
Secretary of General
Directorate of Primary and
Secondary Education Management
Ministry of National Education

Mr. Kiichi TOMIYA
Senior Representative
Japan International Cooperation Agency
Indonesia Office

Mr. Hisayuki Yamamoto
Deputy Team Leader of JICA Project

Figure 3.3.3 Meeting Memorandum on agreement with the Ministry of National Education

(2) The activities and declaration in the first anniversary memorial event

As the first anniversary memorial event, 1) Presentation of papers in the international workshop, 2) Forum and press conference of the declaration and 3) Exhibition of quake-resistant school construction model were conducted. The following are the each content and agreement.

1) Presentation of papers in the international workshop

In the event which was held from 27th September 2010 to 1st October 2010, JICA Project Team suggested the relevant people to promote safer school construction through presentation of papers in the international workshop on 30th September 2010. The comprehensive approach including development of the school construction guidelines, encouragement of government, and legislation was appreciate though many organizations are involved in school reconstruction and disaster management activities.

Figure 3.3.4 International workshop

2) Forum and press conference of the declaration

On 1st October, JICA Project Team had discussion with the relevant persons from the national government and West Sumatra Province about progress of JICA project, its future perspective, and promotion of quake-resistant school construction which was mainly discussed in the forum. The president of West Sumatra Province attended the forum and many relevant persons including the president as a head made agreement and showed declaration in the press conference.

In the press conference, publication of the school construction manual and disaster education handbook for school teachers was presented and the declaration is also presented by the president of the department of West Sumatra Province and JICA Project Team.

The following is the message in the press conference.

> On the occasion of 1st commemoration, we would like to share two products at the "Workshop on Safer Schools for All". The first product is "Manual for Safer School Construction, aiming to be utilized as references and training materials for safer construction. Second one is "Handbook on Disaster Risk Management Education for

Teachers", aiming to be utilized for schools. Following declarations are to be made as the conclusion of the Workshop.

On First Commemoration of Padang Earthquake, following Declaration shall be made as the result of the Workshops on "Safer Schools for All" on 1st October, 2010 to realize Safer Schools for our future generations.

■ Contents of declaration statement

1. JICA Project Team will cooperate with Ministry of Education to prepare standard design to meet earthquake resistant criteria of Government of Indonesia for school construction by May 2011.
2. "Manual for Quality Control during Construction", produced by JICA Project Team shall be utilized in the construction process for eleven schools to be constructed by JICA funded grant aid project. Furthermore, this Manual will be authorized and used as standard manual for future school construction and trainings for engineers and carpenters through necessary discussion with related organizations.
3. In the future, schools will be added functions for evacuation and disaster management. System of designating schools as evacuation sites shall be introduced for schools with earthquake resistant buildings.
4. Schools in West Sumatra Province will adopt "Handbook for School Teachers", produced by JICA Project Team, as formal education material and teachers of all schools in West Sumatra shall conduct disaster risk management education for students.

Press Release

30 Sep, 2010
JICA (Japan International Cooperation Agency) Project Team

1st Commemoration of Padang Earthquake
West Sumatra Government and JICA organizes Workshop
From Sharing Lessons Learnt to Concrete Actions

On the 1st year commemoration of Earthquake off shore of Padang on 30th September, 2009, Technical Support Team for Rehabilitation and Reconstruction Post Disaster in West Sumatra Province, TPT (BNPB), Regional Disaster Management Agency of West Sumatra Provincial Government (BPBD) of West Sumatra Province and Japan International Cooperation Agency (JICA) are organizing a Workshop on 1st October, 2010.

JICA has been conducting seamless support since sending Japan Disaster Response Team from the time of immediate after the disaster to emergency response, recovery and reconstruction phase. JICA is now assisting to construct elementary schools and junior high schools, and these schools can function as evacuation sites.

There were three components in the JICA Project as followings.
Component 1: Model School Reconstruction and Community Based Disaster Risk Management
Component 2: Preparatory (Outline design) study for reconstruction of quake-resistant schools on pilot construction sites
(Construction work will be expectedly implemented under Japanese Grant Aid scheme)
Component 3: Preparation of Manual and Key Requirement for Construction of Safe Schools

The model schools of earthquake resistance and of evacuation function are now under construction. SD08 Sintuk Toboh Gadang is completed in December 2010, and SD23/24 Padang in May 2011. Trainings and Education on Disaster Risk Management has been conducted for school teachers and community people. Evacuation drills, sports festivals using knowledge of disaster risk management are scheduled when school buildings are reconstructed.

On the occasion of 1st commemoration, we would like to share two products at the "Workshop on Safer Schools for All". The first product is "Manual for Safer School Construction, aiming to be utilized as references and training materials for safer construction. Second one is "Handbook on Disaster Risk Management Education for Teachers", aiming to be utilized for schools. Following declarations are to be made as the conclusion of the Workshop.

Contact Person
Mobile: 081-3887-96475
Mr. Hisayuki Yamamoto
Deputy Project Manager
JICA Project Team

Figure 3.3.5 Press release document and the situation in press conference

DECLARATION
ON FIRST COMMEMORATION
OF PADANG EARTHQUAKE

On First Commemoration of Padang Earthquake, following Declaration shall be made as the result of the Workshops on "Safer Schools for All" on 1st October, 2010 to realize Safer Schools for our future generations.

1. JICA Project Team will cooperate with Ministry of Education to prepare standard design to meet earthquake resistant criteria of Government of Indonesia for school construction by May 2011.
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3. In the future, schools will be added functions for evacuation and disaster management. System of designating schools as evacuation sites shall be introduced for schools with earthquake resistant buildings.
4. Schools in West Sumatra Province will adopt "Handbook for School Teachers", produced by JICA Project Team, as formal education material and teachers of all schools in West Sumatra shall conduct disaster risk management education for students.

Prof.Dr.H. Irwan Prayitno, Psi,M.Sc
Governor of West Sumatera Province

Mr. Motofumi Kohara
Resident Representatives
Japan International Cooperation Agency

Mr. Bakri Beck
Deputy Chief for Rehabilitation and Reconstruction
National Disaster Management Agency (BNPB)

Mr. Harmensyah
Head Regional Disaster Management Agency of
West Sumatra Provincial Government (BPBD)

Mr. Devi Kurnia
Head of Law Bureau, West Sumatra Province

Mr. Dody Ruswandi
Head of Public Works
West Sumatera Province

Mr. Asrul Ilyas
Monitoring and Evaluation Team
Technical Support Team for Rehabilitation and Reconstruction Post Disaster in West Sumatra
TPT (BNPB)

Mr. Musdek
Head of TK/SD Division
Padang City Education Office

Mr. Federda
Head of Curriculum Division
West Sumatera Provincial Education Office

Mr.Syamsulrizal
Department Head District Education office
Of Padang Pariaman District

Mr. Didi Aryadi
Assistant Administration
Padang City

Figure 3.3.6 The declaration signed by the president of West Sumatra Province and other relevant persons

3) Exhibition of quake-resistant school construction model

Based on the standard design of quake-resistant school building, the 1 meter real-size model of structure and reinforcing bar from the basement which shows the detail was made and exhibited in the booth. The materials of the model are same one used in actual construction site. The booklet on quake-resistant building was distributed to relevant people and its explanation was also given to them. The booklet was appreciated. 500 booklets which are all booklets prepared for the event were completed to be distributed.

Figure 3.3.7 Exhibited mode

Figure 3.3.8 People who visited the booths
(left: Japanese ambassador and right: local community and others)

3.4 Future perspective and visions

(1) Promotion factors and inhibition factors in the activities

In the current project, the specification is mentioning to conduct “Consideration on promotion and expansion of safer school construction by community participatory”, to consider promotion strategy and framework to promote proposed quake-resistant school in Indonesia and to propose relevant government sectors and donors, and to propose monitoring method and framework.

The specification does not mention encourage to legislate safer school construction. But the project team regarded reconstruction process was effective duration and the team developed the guidelines ahead of the schedule and encouraged the governments.

Revision and legislation of the regulation of West Sumatra is the promotion factor. The head of the department of public department gathered relevant staffs and told them to utilize the construction manual developed in JICA project. In addition, he made efforts to integrate the construction manual in the legislation. As the results, integration is not proper. But workability is ensured through attaching the manual to the contract under the Ministry of Public Works rather than integrating the manual in the regulation.

The Ministry of Public Works has realized necessity of providing training to construction companies or workers, using the manuals. It is the promotion factor.

There is inhibition factor. The heads of department of public works and department of education of West Sumatra Province have many times of business trips. They stay Padang in few days and are busy. Therefore, it was difficult to meet when needed. The person in charge have the working fields in Padang and Padang Pariaman and have activities of Component 3 in parallel. Because of distance between Jakarta and West Sumatra and short term assignment, they could not focus on activities of Component 3 and it was difficult to discuss intensively. Activities got achievement which had not been in the specification but it was possible to show more progresses if there was close and continuous relationship with the head or other important person.

(2) Future perspective and visions

In May 2011, the last consultation with the vice president of the Ministry of Education was done. He mentioned it was not easy to get additional budget but he hoped to continue internal procedure. As for the head who had had consultation with the Ministry of Public Works, the decided missions were changed and he got the role to manage construction of public buildings. Therefore, JICA Study Team was considering how he should be made to have binding authority and encouraging him whenever the team had opportunities. But he mentioned it is not easy to get budget.

There is big difference between understanding and recognition of the central government and actual field because the government is far from the fields. But the department of public works of

West Sumatra Province is changing the building code and legislating it. It is possible to start in West Sumatra Province according the provincial regulation. The head of the department of education of West Sumatra Province is working to utilize the school construction guidelines and construction manual in school construction.

Ass JICA Project Team, it is important to make and increase actual cases of quake-resistant building even if cases are increased gradually. It can lead to the next step. The head of the department of education of Padang City felt difference between quake-resistant building and other building through actual one. It is important that more people understand and share the difference of actual quake-resistant buildings. To achieve it, as many as actual building should be constructed through whatever we/they can like adding reconstruction budget for this purpose if possible. It is immensely important to see and realize actual building. Some persons became more active through seeing actual building during consultation. If it is possible to apply the additional budget for quake resistance to the central government, the government is expected to approve the budge even for a school as special example in the future.

There is possibility to show more effects by follow-up. It is strongly hoped to make the framework in order to monitor the situation in West Sumatra Province and to support when needed. Especially, Training in field based on the construction guidelines is important. As the follow-up activities, persons who had many experiences in fields should provide training and raise more trainers, targeting many engineers employed by construction companies and masters. Other promotion factor is construction association. The association is providing seminar and training with engineers and workers and publishing the certificate based on exam. The association is organization covering national level and can promote in whole area of Indonesia. In addition, if education materials of quake-resistant building for seminar are developed, the association can conduct this kind of seminar. The association is expected to utilize their own network of the association and promote the seminar of quake-resistant building in whole area of Indonesia. But it is necessary that the first training should be implemented so that the quality is controlled. It takes long time that people realize necessity of quake-resistant building, that the project is practicable within assigned works for governments, and that actual actions are accelerated. Even if people realize necessity of quake resistance, they can not do anything without any budget. It is necessary to select vulnerable area and to conduct project on quake-resistant school construction with a loan.

ANNEX

JAPAN INTERNATIONAL COOPERATION AGENCY

URGENT PROJECT ON RECONSTRUCTION OF SCHOOLS CONSIDERING
QUAKE-RESISTANCE AND COMMUNITY BASED DISASTER RISK MANAGEMENT
IN THE PROVINCE OF WEST SUMATRA
IN THE REPUBLIC OF INDONESIA

QUALITY CONTROL MANUAL
REINFORCED CONCRETE WORK

August 2011

Part 1. Basic Knowledge..... 1-1

Part 2. Execution 2-1

PART-1 BASIC KNOWLEDGE

1-1 What is the Concrete?

1-1-1. The Concrete is the most popular construction material in the world because;

- Any kind of shape can make
- Easy to get materials
- Strong and durable
- At any places (on the ground, in the sea, in the river and under ground etc) can make.
- Low price

1-1-2. The Concrete is not same to Cement past and Mortar

- “Cement past” is composed by cement and water only.
- “Mortar” is composed by cement, water and sand only.
- “The concrete” is The concrete is mixing materials with cement, water, sand and stone.

Table-1 Composition of Cement past, Mortar and Concrete

Name	Materials
Cement Paste	Cement, Water
Mortar	Cement, Water, Sand
Concrete	Cement, Water, Aggregate (Sand, Gravel stone)

1-1-3. The concrete has high durability

Table-2: Standard durability of the concrete depend on the concrete strength

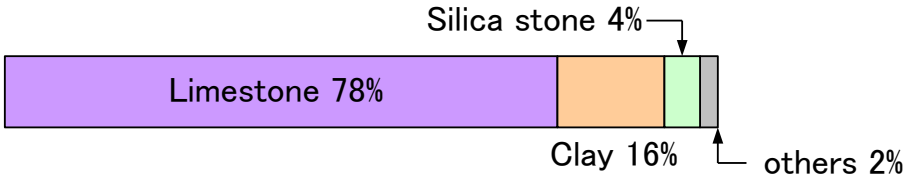
Durability class	**Planed durability period**	**Required Concrete strength (N/mm^2)**
Short life span	Approxi 30 years	18
Normal life span	Approxi 65 years	24
Long life span	Approxi 100 years	30
Most long life span	Approxi 200 years	36

- ◆ Standard durability of the concrete is different by its strength as shown Table-2.
- ◆ The concrete made by correct knowledge and procedure has long durability of more than 100 years.
- ◆ Normally, the building is designed by 21N/mm^2 to 24 N/mm^2, its target of durability is around 65 years.
- ◆ However, even if use concrete strength of 24N/mm^2 or 30 N/mm^2, the standard durability of the concrete which made by incorrect knowledge and procedure is seriously down.

1-2 Character of the Cement

1-2-1 Main material

Fig-1: Main material of Portland cement is Limestone



1-2-2 Main Ingredients of Portland cement

Tabel-3 Main ingredient of the Portland cement

SiO_2	Al_2O_2	Fe_2O_3	CaO	MgO	SO_3	Others
21.06%	5.15%	2.80%	64.17%	1.46%	2.02%	

CaO: Calcium oxide/SiO_2: Silicon dioxide/Al_2O_2: Aluminum oxide/ Fe_2O_3: Ferric oxide/ SO_3: Sulfur trioxide/ MgO: Magnesium oxide

1-2-3 Main Chemical compound

Tabel-4 Main chemical compound of the Portland cement

Mark		C_3S	C_2S	C_3A	C_4AF
Character	Speed of hydration	Very fast	Fast	Slow	Fast
	Period of revelation of strength	**Within 1 day**	**3 to 7 days, and continue up to 28 days**	**After 28 days**	Not affect to strength

C_3S : Silica lime/C_2S:Cilica lime/C_3A:Aluminate lime/ C_4AF:Iron Aluminates lime

As shown above table, the speed of hydration of;

- **C_3S is very fast (within one day from concrete pouring day)**
- **C_2S is fast (3 to 7 days and continue up to 28 days from concrete pouring day)**
- **C_3A is very slow (after 28 days from concrete pouring day)**

Thus, the concrete strength doesn't become hard at one time.

Mainly, from first day after pouring concrete and up to 28days continue hydration, even after 28days continue hydration

⇩

Therefore, to continue curing (sprinkle water) work up to 28days at least is very important.

1-3 Typical character of the Concrete

1-3-1 Strong to Compression force and Weak for Tension force, Bending moment and shear force.

Table-5 Typical character of the concrete

Kind of stress	Character
Compressive force	Strong
Tension force	Weak
Bending moment	Weak
Shear force	Weak

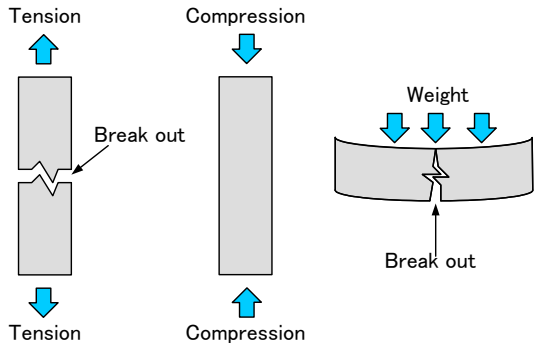


Fig-2 Typical character

1-3-2 Weak for deformation

The concrete have a crack due to stretch of only 0.01 to 0.02% (=0.1mm to 0.2mm per 1.0m).

1-3-3 Weak for salty content

The concrete is strong alkaline material; therefore the concrete is weak for salty content.

- ◆ Target of permissible amount of salty content in the concrete is less than 0.3 kg/m^3.
- ◆ Before mixing concrete, to inspect the amount of salty content in the mixing water, sand and aggregate.
- ◆ If, the concrete contain lot of salty content, the durability of the structure seriously reduces.

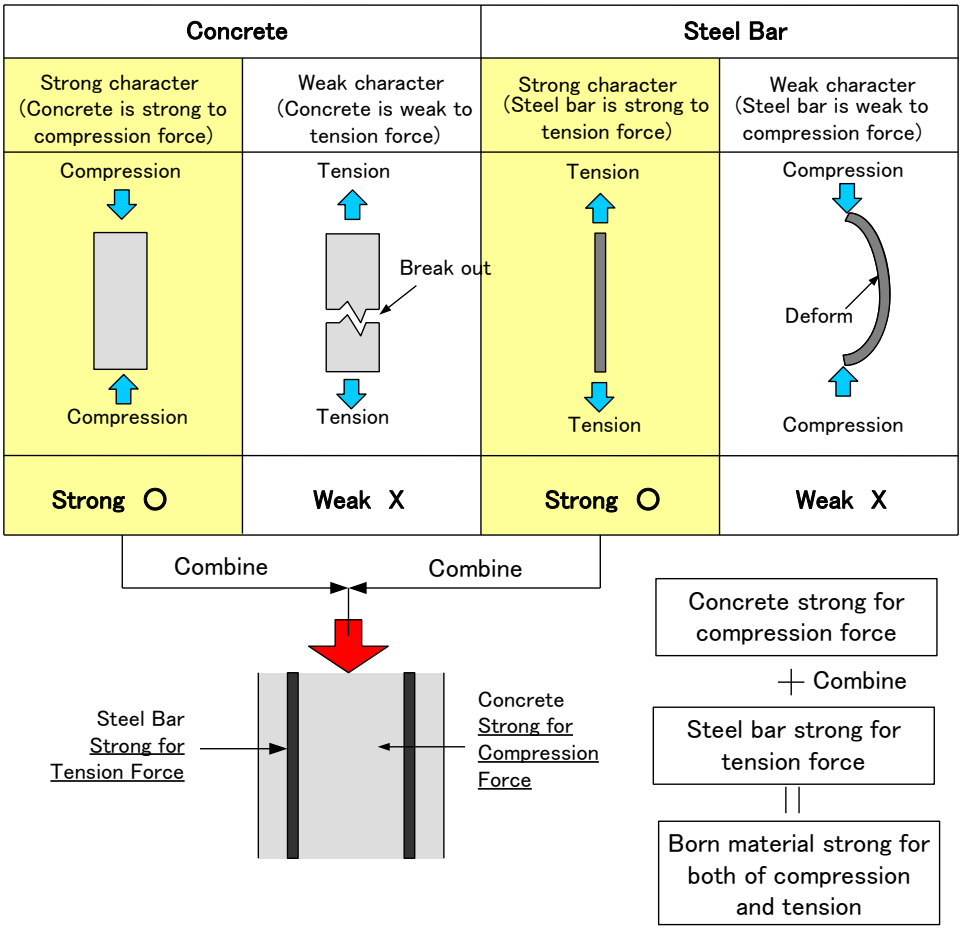
Fig-3 Damaged column by salty

1-4 What is the Reinforced Concrete (RC)?

1-4-1 Characteristic of the Concrete and Steel bar

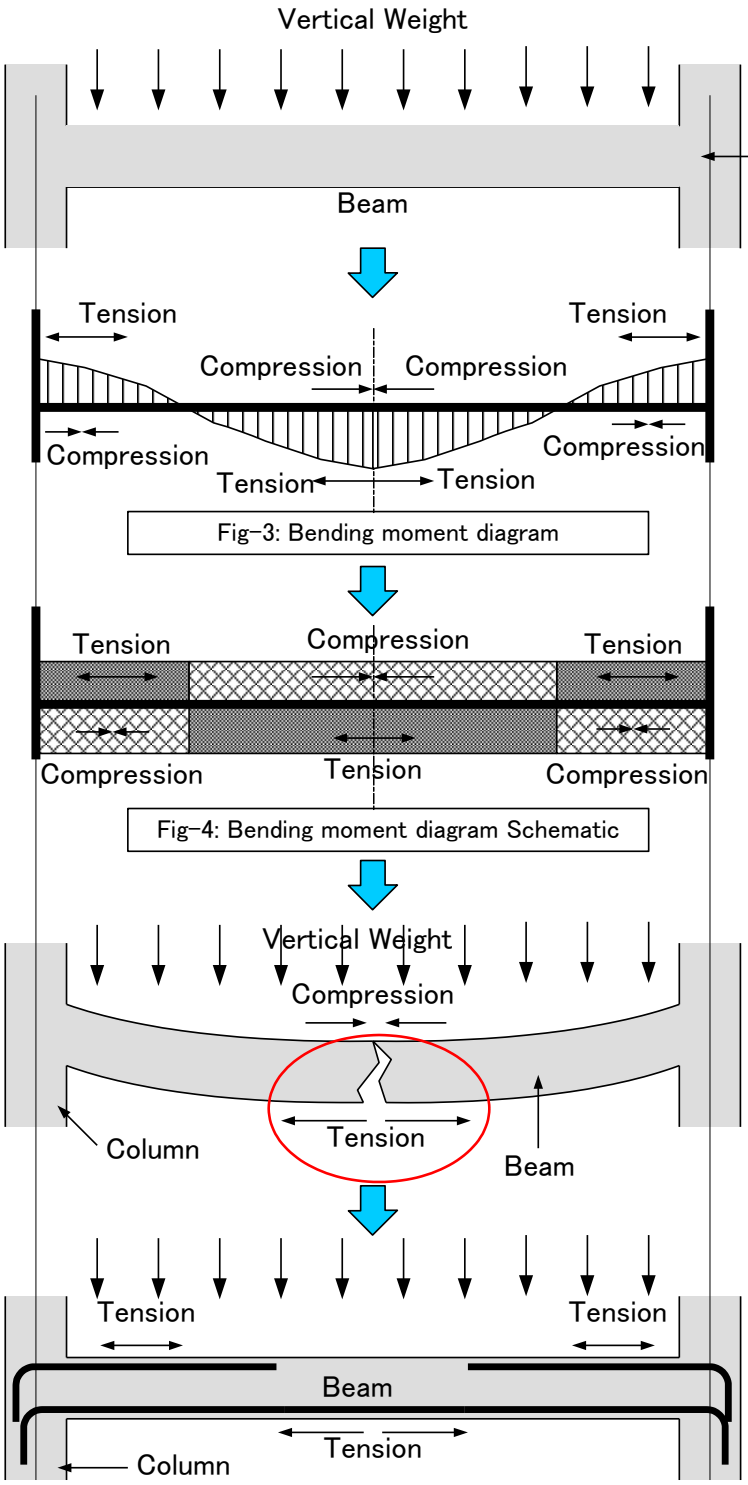
- Reinforced Concrete (RC) is composed by concrete and steel bar.
- The Concrete has a character of strong to compression force and weak to tension force.
- Steel bar has a character of weak to compression force and strong to tension force.
- Thus, the Reinforced concrete is the material which has both of strong character of concrete and steel bar as shown Fig-4.

Fig-4: Character of the Concrete and Steel Bar



1-4-2 Mechanism of Reinforced Concrete (RC)

Reinforced Concrete is the combined structure of the concrete strong in the compression and steel bar strong to the tension force.



Due to Vertical load such as dead load and live load,
The bending moment stress occurs as shown Fig-3.
Tension force occurs on the;
- Top of the beam of the end part and
- Bottom of the beam of the center part.

Compression force occurs on the;
- Bottom of the beam of the end part and
- Top of the beam of the center part

If no reinforcing bar is installed, the beam is broken due to Tension force

If, some steel bar are installed in the concrete
The beam not be broken

Fig-5 Mechanism of the reinforced concrete

1-4-3 Importance of Bond strength between Concrete and Steel bar

- The medium that combines of the concrete and steel bar is bonding strength of the concrete.
- Therefore, execute concrete work so that to get enough bonding strength surroundings of the steel bar is very important.

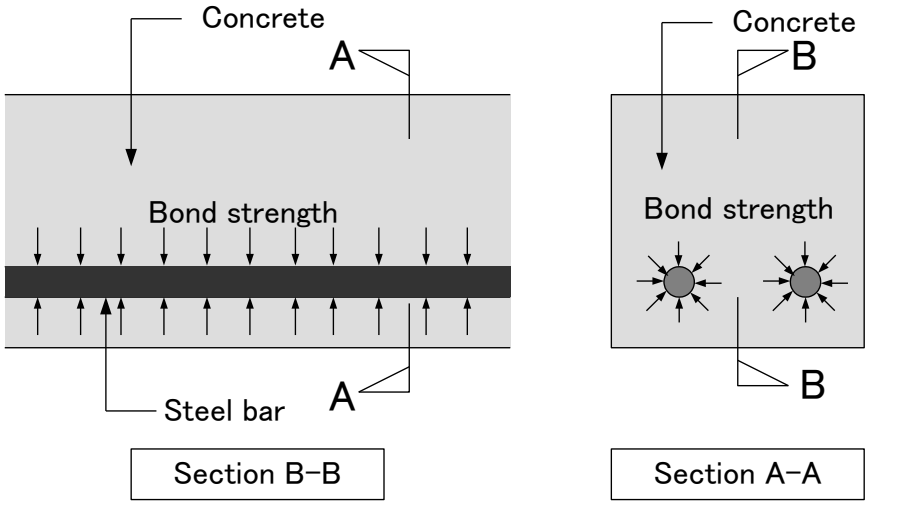


Fig-6 Adhere (bonding) re-bars and concrete

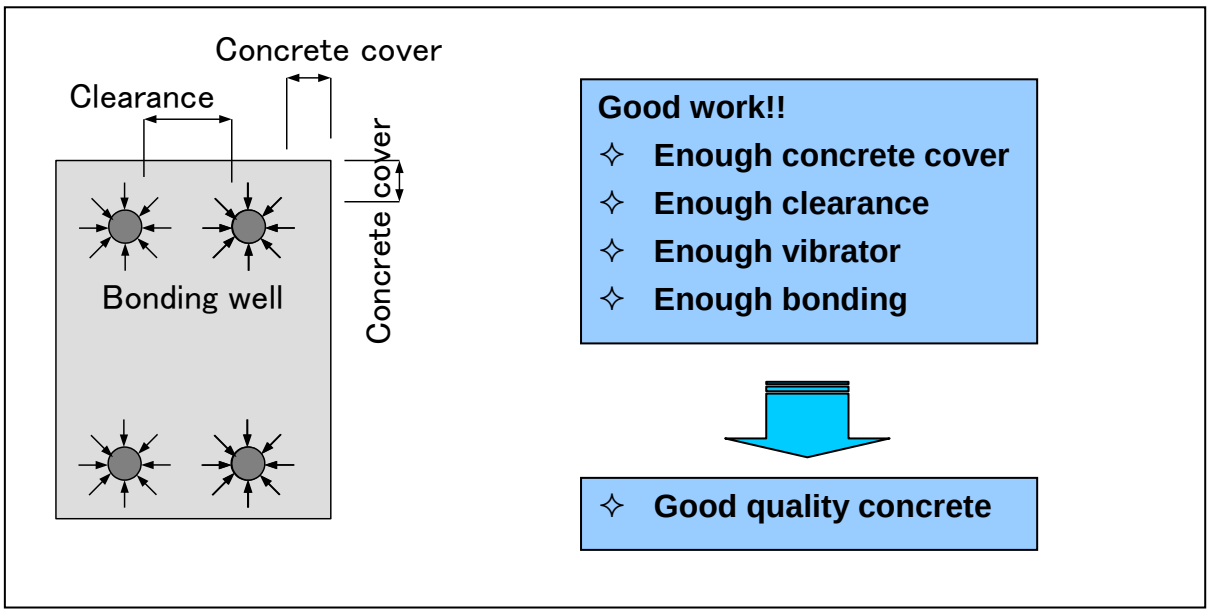
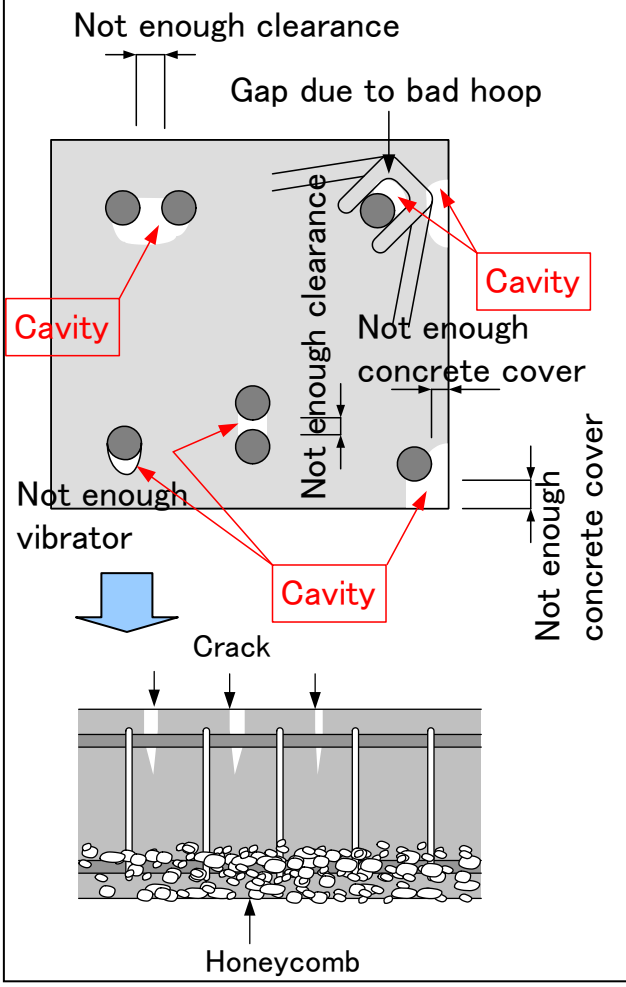


Fig-7 Example of the bad concrete work



Bad work!!

- Not enough clearance
- Not enough concrete cover
- Not enough vibrator

✧ **The concrete can not surround the bars**

✧ **Many cavity around bar outbreak**

✧ **Bonding stress not enough**

✧ **Concrete quality down (poor)**

1-4-4 Importance of concrete cover

- The concrete has strong alkaline character; therefore, the concrete surface has neutralization due to carbon dioxide, water and other toxic substance in the air.
- The neutralization of the concrete is connected directly to durability down.
- The neutralization outbreak the concrete cracks.
- Concrete cracks outbreak the corrosion to the steel bar.
- Finally, the durability of the structure is going down rapidly.

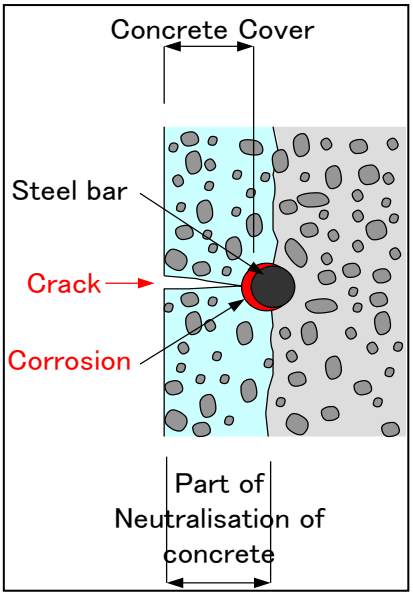


Fig-8 Section of the concrete

◆ The speed of the neutralization is follows;

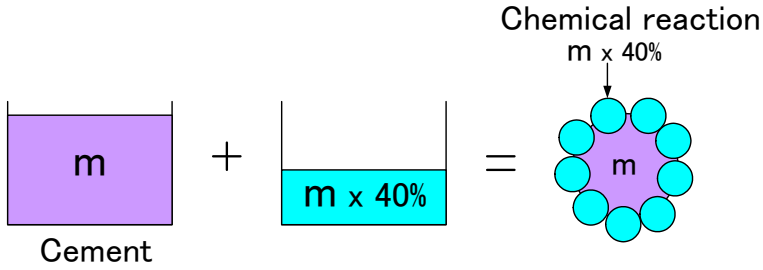
Table-6: Relation of thickness of concrete cover and Standard durability

Thickness of concrete cover	Standard durability
Up to 1.0cm	Around 7 years
Up to 2.0cm	Around 30 years
Up to 3.0cm	Around 60 years

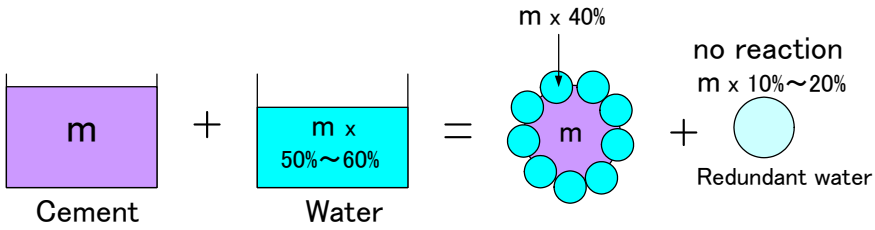
It means, to keep enough concrete cover is very importance factor for the durability.

1-4-5 Necessary amount of the water

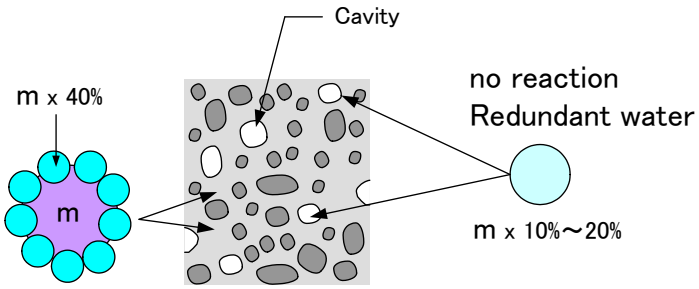
Cement make chemical reaction with water approximately 25% and absorb water approximately 15% of its mass (m), totally react with water approximately 40%. However, actually, the concrete is mixing with the water of amount of m x 50～60%. It means, around 10 ～20% of water become [redundant water] cause of big bubble in the concrete. Big bubbles reduce concrete strength significantly.



Necessary amount of the water for chemical reaction is;
m x 40%



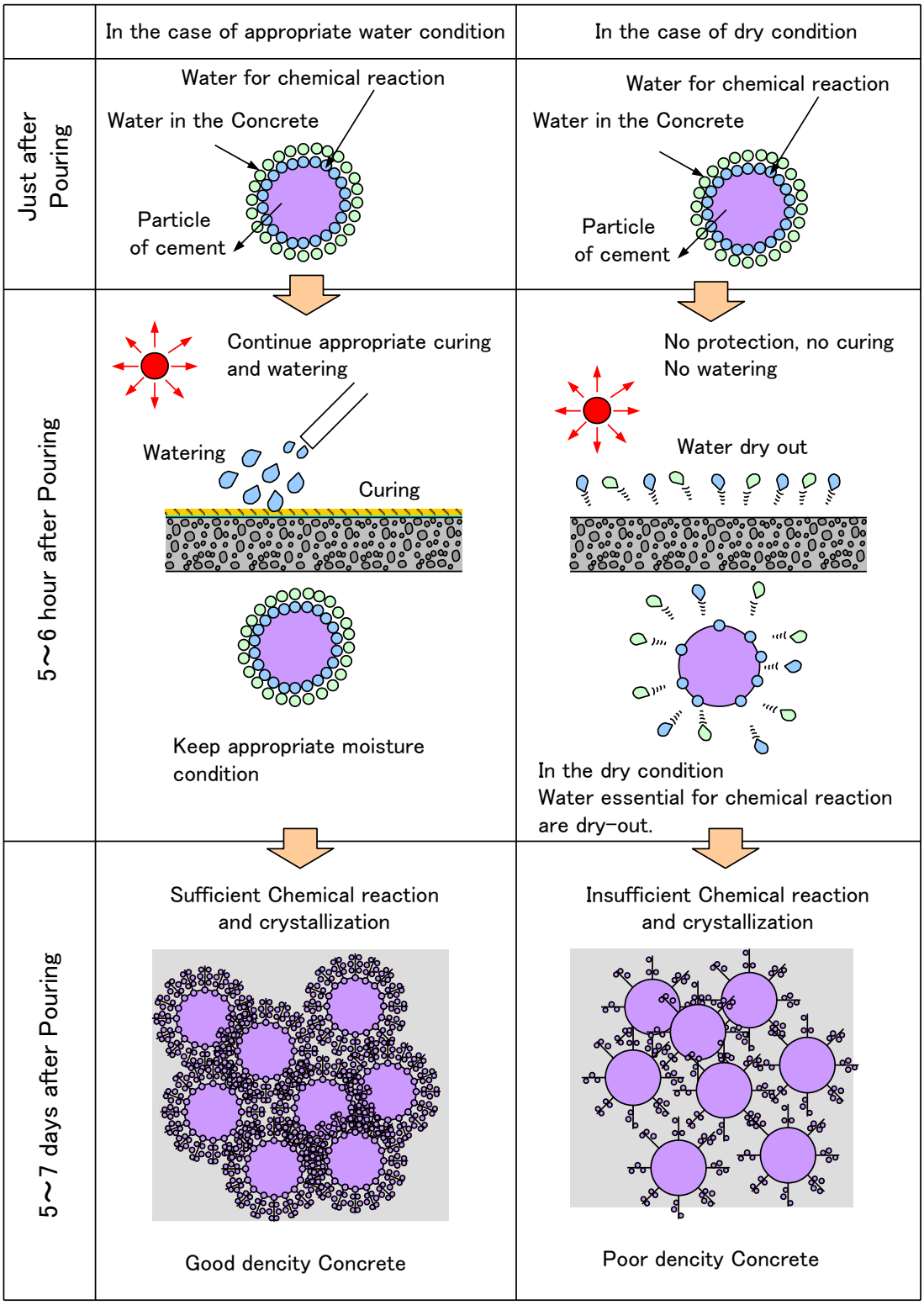
Necessary amount of water for chemical reaction is around m x 40%, therefore, if mix 50% to 60% water of the mass of cement, 10% ～20% water has no chemical reaction (Redundant water).



Around 10% ～20% of redundant water cause of make cavity in the concrete and cause reduce strength of the concrete, therefore, too much water is not good for the concrete.

1-4-6 Importance of the Continue curing and watering after pouring concrete

In order to make good quality concrete, to keep appropriate moisture condition after pouring concrete by curing and watering is very important.



1-5. Trial mixing concrete

1-5-1. Purpose of the trial mixing

(1) To control quality of the concrete is the most important item

(2) To confirm not only 28 days strength but also quality of the fresh concrete is very important.

(3) Especially this clause applies to the site mixing concrete.

(4) In the case of ready mixed concrete produced by authorized factory, trial mixing may not necessary.

Table-7 Main items to be confirmed by the trial mixing concrete

	Items	Judgment and/or standard
(1)	Slump	±1.0 cm of the technical specification
(2)	Air contents	4.5%±1.0 % (=3.5% to 5.5%)
(3)	Concrete temperature	By thermometer
(4)	Salinity contents	Amount of chloride ions shall less than 0.3kg/m^3
(5)	Segregation	Visual observation
(6)	Compression strength	Compression test (Refer to 1-6-6)

(5) Basic factors of concrete strength

1) Amount of cement (C)
2) Amount of Water (W)
3) Amount and density of stone
4) Amount of sand

✧ If, water and cement ration (W/C) is small (=Amount of cement is big)
◎ Concrete strength become high
◎ Durability become long time
◎ Slump become small → Hard concrete → Suitable for Civil work
× Concrete work for building construction become difficult
× Liable to have crack

✧ If, water and cement ration (W/C) is big (=Amount of water is big)
◎ Concrete strength become low
◎ Durability become short time
◎ Slump become big→ Concrete become soft→Concrete pouring work become easy
× Liable to have crack because of much water→Cement milk leak easily →Outbreak many honeycomb

✧ If, amount of sand is big
× Slump become big
× Concrete strength become low

✧ If, amount of stone is big
◎ Slump become small
◎ Concrete strength become high

✧ If, density of stone is light
× Concrete strength become low

✧ If, air content is big
× Concrete strength become low

Thus, the concrete strength is become high and low depend on various factor and condition, therefore, the planning of mix proportion is the first step for making high quality concrete

1-5-2 Procedure of mix proportion design

(1) Decide maximum size of aggregate considering the dimension on structural elements.
(2) Decide amount of air contents (target max 4.5%), kind of cement and slump.
(3) Decide target concrete strength considering design strength.
(4) Decide water (W) and cement (C) ratio (=W/C).
(5) Decide amount of water
(6) Decide amount of cement
(7) Decide unit weight of coarse arrogate (stone) and fine aggregate (sand)

1-5-3 Design strength and Target strength for quality control

(1) Basically Concrete strength is not allowed to have lower strength than design strength.
(2) However, actually, even if same mixing proportion, concrete strength in not always same, sometime lower than design strength and sometimes much higher than design strength.
(3) Therefore, in order to satisfy the design strength, it necessary to make target strength which is considered uneven quality of the concrete.
(4) Recommendation of the Target strength is follows;

Fq= Fc + 3.0 N/mm^2

For example;
In the case of Fc=250K → Target strength of mixing proportion shall Fq=280K

Note:

- ✧ Design strength (Fc) is required strength by the structural design.
- ✧ Target strength (Fq) is the strength for quality control of the concrete considering quality down due to negative factor during concrete mixing and pouring work.

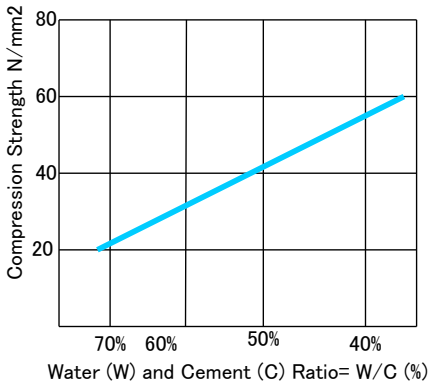
1-5-4 The key-points for making good concrete.

Table-8 The key-points for making good concrete.

Materials		Key points
(1)	Water	**Reduce water as much as possible**
(2)	Aggregate (stone)	**Increase stone as much as possible**
(3)	Hardness (Slump)	**Make hard as much as possible**

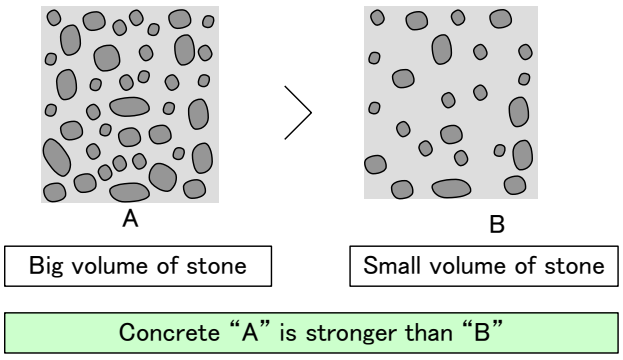
(1) Reduce water

In the case of the soft concrete which contain lot of water is liable to crack due to redundant water for chemical reaction. As shown figure, the compression strength increase inversely proportional to the water and cement ratio.



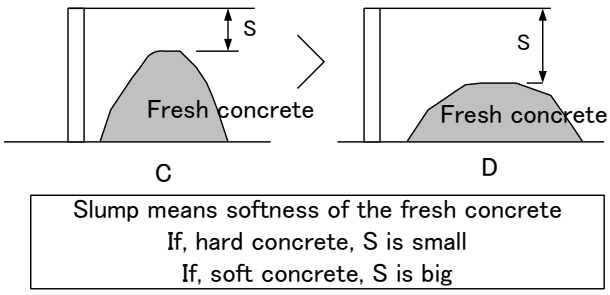
(2) Increase stone

The durability of A (Concrete contain big volume of stone) is higher than B (Concrete contain small volume of stone).



(3) Make hard concrete

The concrete which has small slump (hard concrete) is of even quality due to no material (cement and stone) separation.



1-5-5 Preparation and method of trial mixing

Step1. Planning Mixing Proportion

Step2. Trial Mixing by Mixer

Step3. Check for Moisture Content and Slump

Step4. Check for Air Content by Tester

Step5. 6 Test Pieces Sampling for Strength Test

Step6. Concrete Compressive Strength Test

1-5-6 Concrete Test

(1) Compressive test

1) Check the compressive strength
   - ✧ 1 time each work segment
   - ✧ 6 cylinders for 1 test (3 for 7 days, 3 for 28 days)

2) Test piece
   - ✧ Height of test piece is 2 times of its width
   - ✧ Fill the concrete in the mold divided into 2 layers

Compressive Strength Test Sampling Image

Compressive Strength Test Image

3) Method
   - ① Clean the cylinder mould and coat the inside lightly with form oil, then place on a clean, level and firm surface, ie the steel plate.
   - ② Collect a sample. See Sampling
   - ③ Fill 1/2 the volume of the mould with concrete then compact by rodding 25 times. Cylinders may also be compacted by vibrating using a vibrating table. Cement Concrete & Aggregates Australia 12 CONTENTS Concrete Basics Concrete Testing 12 The Compression Test continues on the next page
   - ④ Fill the cone to overflowing and rod 25 times into the top of the first layer, then top up the mould till overflowing.
   - ⑤ Level off the top with the steel float and clean any concrete from around the mould.

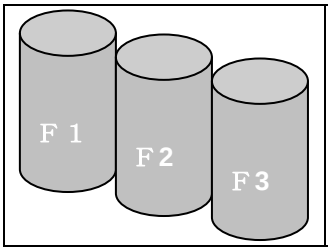
⑥ Cap, clearly tag the cylinder and put it in a cool dry place to set for at least 24 hours.

⑦ After the mould is removed the cylinder is sent to the laboratory where it is cured and crushed to test compressive strength.

4) Judgment of the compression test result

✧ Concrete shall be required that the average of 3 pieces is more than design strength + 3N/mm2

The result of the compression test



Average of 3 pieces =(F1+F2+F3)/3 shall be ≧ Fq (Design Strength + 3N/mm2)

If, less than Fq;

5) If Trial Mixing was failed…….

✓ Check, confirm and analyze again about following points.
✓ Analyze mixing proportion. Water-cement ratio.
✓ Unit water contents…etc.
✓ Check for cement specification, date and conditions.
✓ Wet or dry, Fresh or old…etc.
✓ Check for aggregate specifications and conditions.
✓ Grain size, Water contents…etc.
✓ Analyze water contents and slump at the mixing concrete time.
✓ Confirm concrete curing method after mixing concrete.

Concrete test again

(2) Slump test

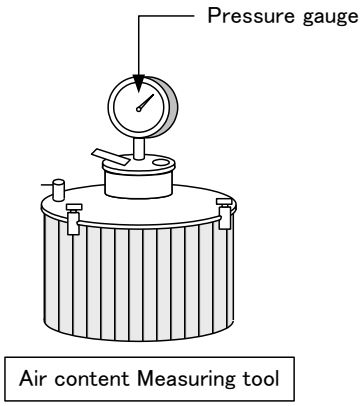
1) Clean the cone. Dampen with water and place on the slump plate. The slump plate should be clean, firm, level and non-absorbent. Collect a sample of concrete to perform the slum test.
2) Stand firmly on the footpieces and fill 1/3 the volume of the cone with the sample. Compact the concrete by 'rodding' 25 times. Rodding means to push a steel rod in and out of the concrete to compact it into the cylinder, or slump cone. Always rod in a definite pattern, working from outside into the middle.
3) Now fill to 2/3 and again rod 25 times, just into the top of the first layer.
4) Fill to overflowing, rodding again this time just into the top of the second layer. Top up the cone till it overflows.
5) Level off the surface with the steel rod using a rolling action. Clean any concrete from around the base and top of the cone, push down on the handles and step off the footpieces.
6) Carefully lift the cone straight up making sure not to move the sample.
7) Turn the cone upside down and place the rod across the up-turned cone.
8) Take several measurements and report the average distance to the top of the sample.If the sample fails by being outside the tolerance (ie the slump is too high or too low), another must be taken. If this also fails the remainder of the batch should be rejected.

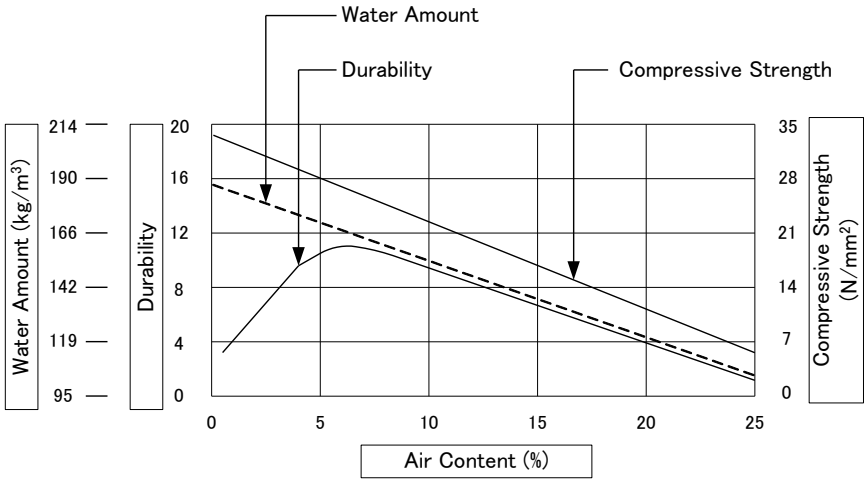
1 → 2 → 3 → 4

(Every procedure should be completed in less than 2.5 minutes)

(3) Air content test

1) Air content test shall be done at the same time of the slump test.
2) If, air contents increase, concrete compression strength decrease
3) Appropriate air contents shall 4.5 % standardly.

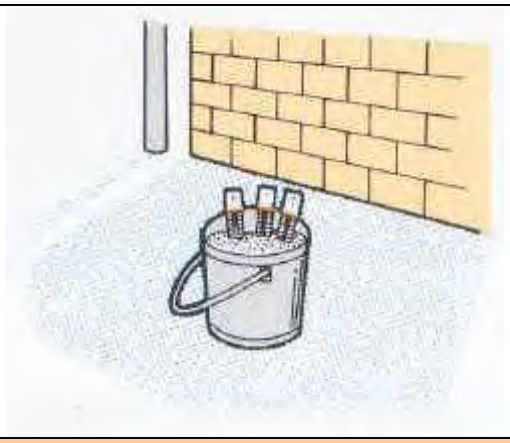




(4) Chloride content

Check of chloride content of concrete

1) Test each work segment for placing concrete
2) Volume of chloride content is **less than 0.3kg/m^3**
3) Test must be done in the shade

	
Test tool	**Test image**

Chloride Test Strip

PART-2 EXECUTION

2-1 Concrete works

2-1-1. Watering to the form before pouring concrete.

Dried form absorb water of the fresh concrete, and caused poor density concrete, Therefore, before pouring concrete, to give the water to the dried form as shown Fig-10 is very important for product high density concrete. If pouring concrete without watering, water contents of the fresh water absorbed by the dried form and concrete density become very poor as shown Fig-11.

Fig-10, Essential Procedure of pouring concrete for product high density concrete

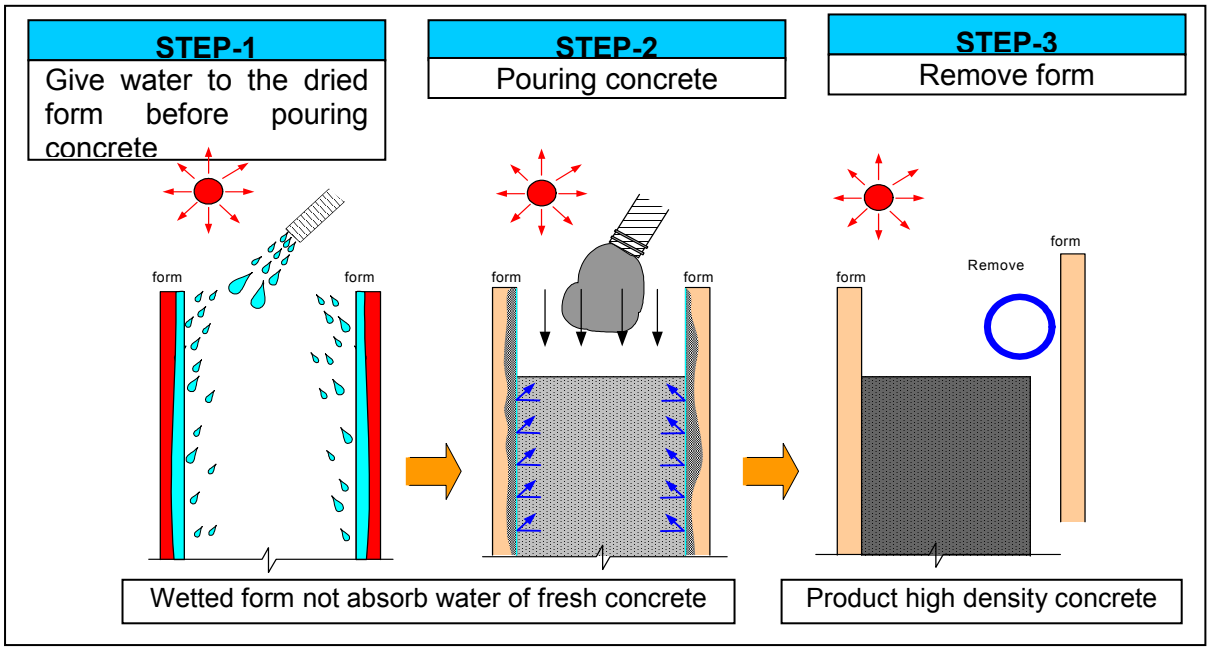
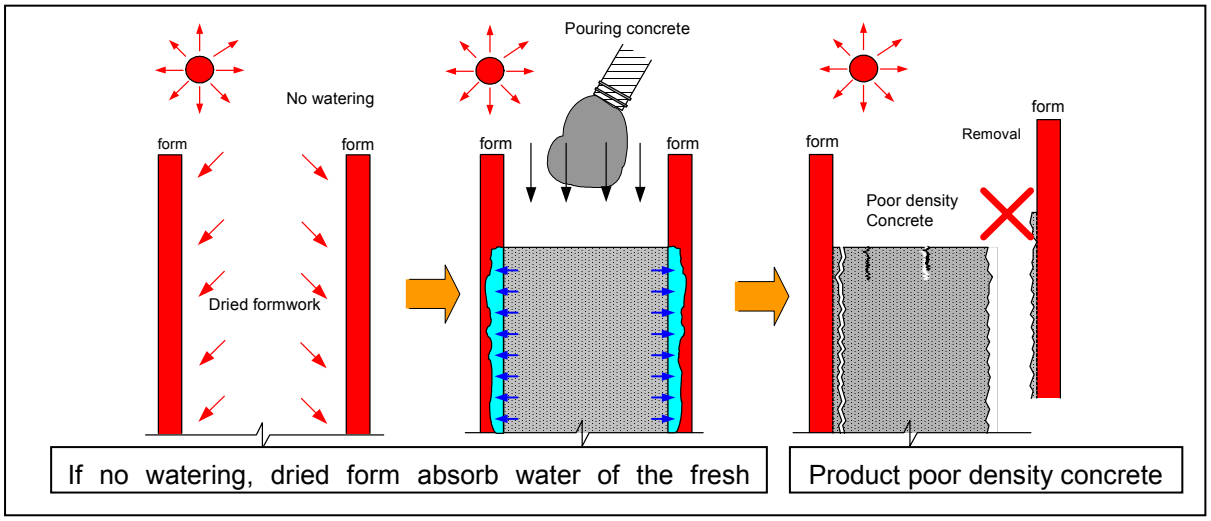


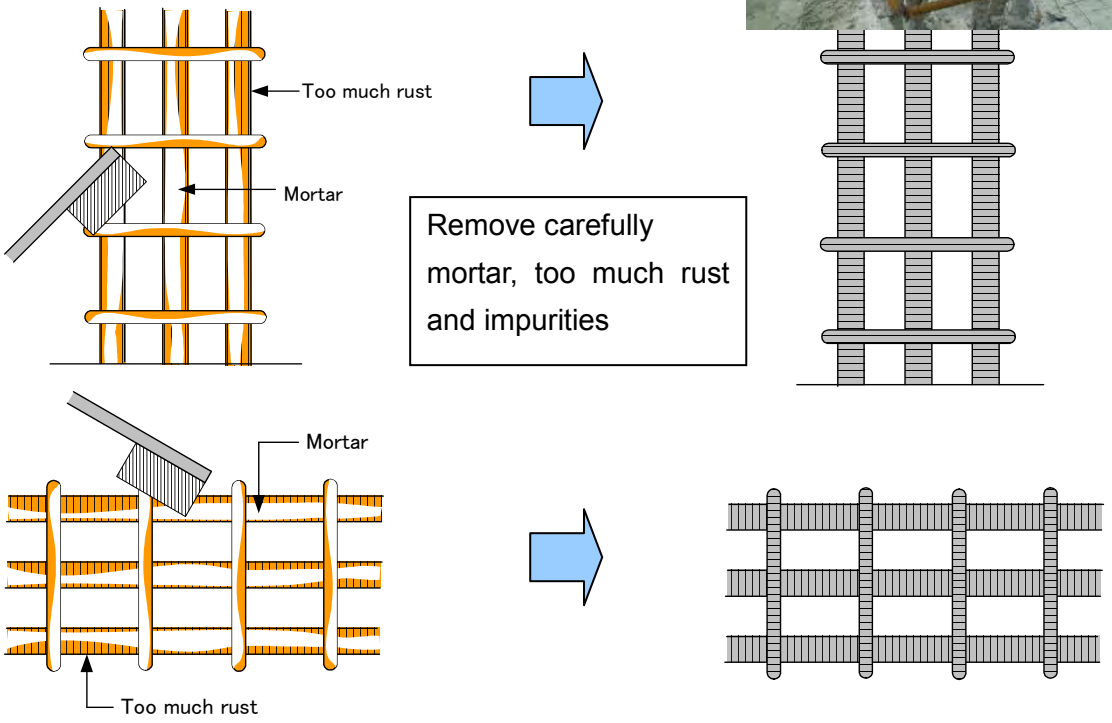
Fig-1, Inappropriate Procedure of pouring concrete



2-1-2. Clean up

(1) Clean up of the Reinforcing bar

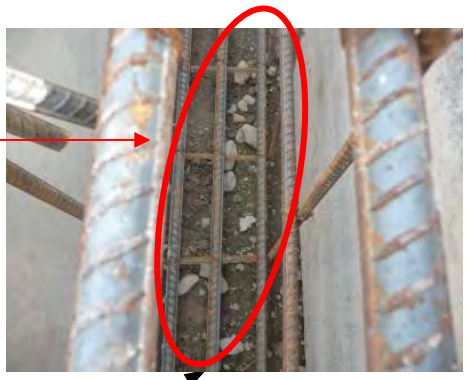
Before pouring concrete, remove the mortar, too much rust and impurities that adhere to the reinforcing bars.

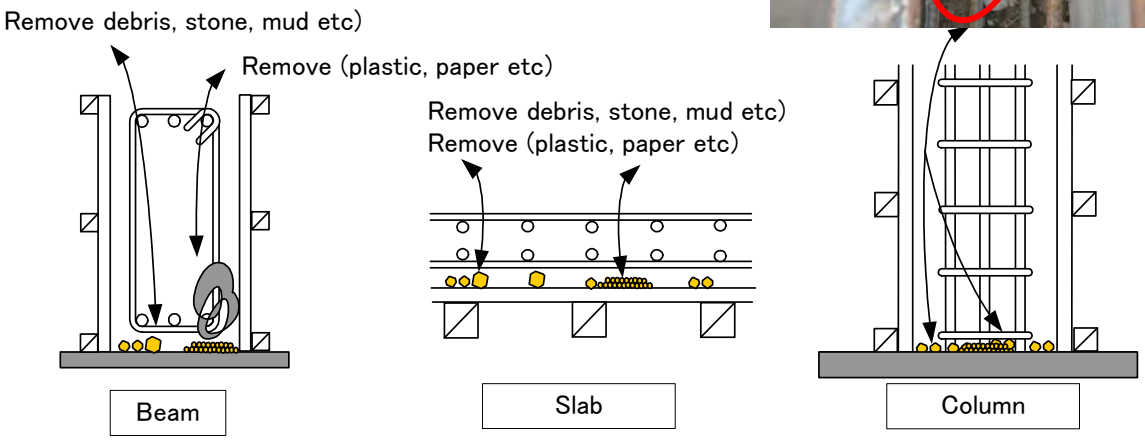


Don’t pour the concrete before removing the mortar, too much rust and impurities.

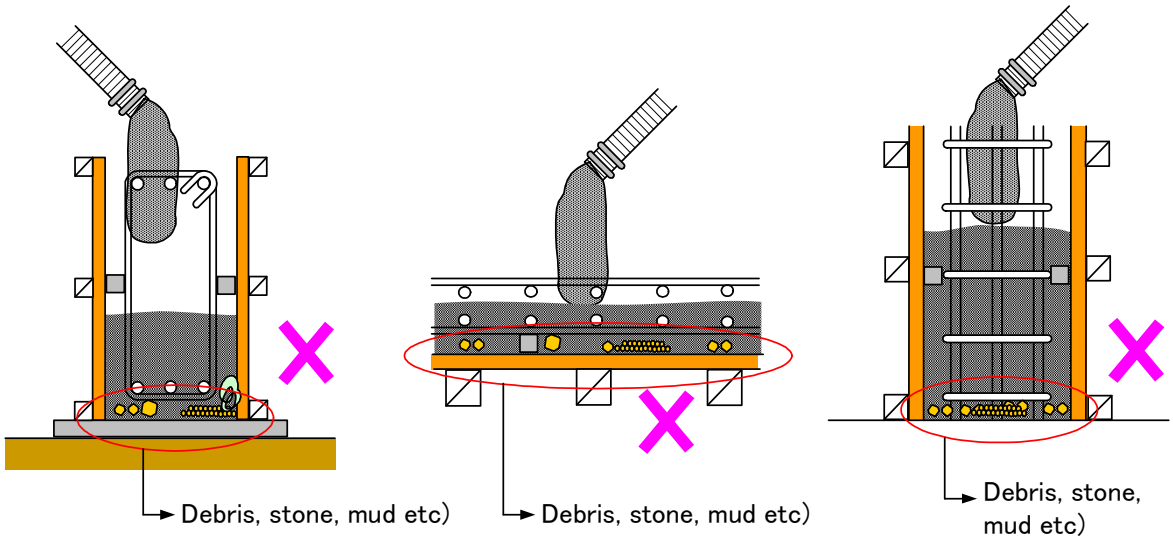
(2) Remove debris, sand, mud, stone, paper, vinyl etc

Stone, mud, debris, paper, vinyl etc





Do not the concrete before removing the stone, debris, paper and vinyl etc.



2-1-3. Pouring concrete for column

(1) Don’t shoot the concrete directory from the top of the column

The pouring concrete for column shall use vertical shoot and discharge the fresh concrete carefully.

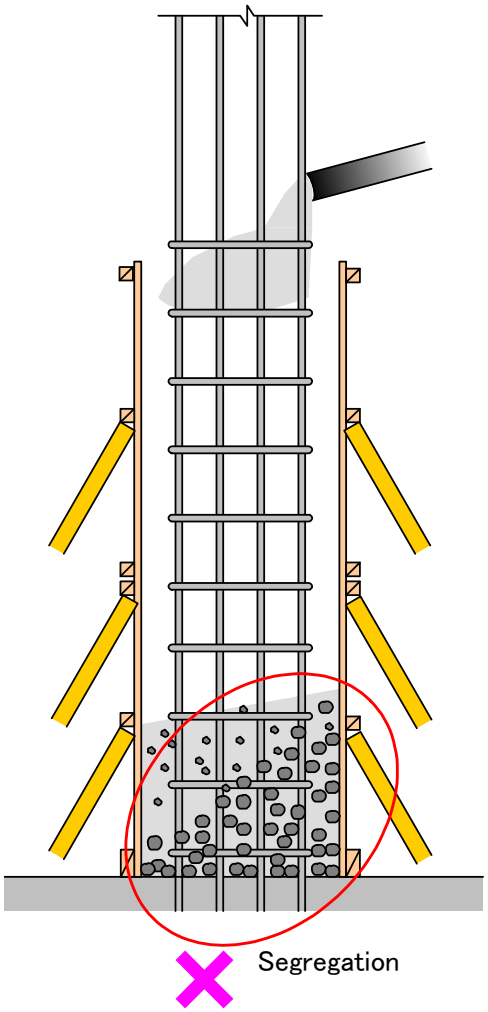


Fig-12: Direct pouring

Don’t shoot the concrete directory from the center of the column so that to avoid the Segregation at bottom of the column

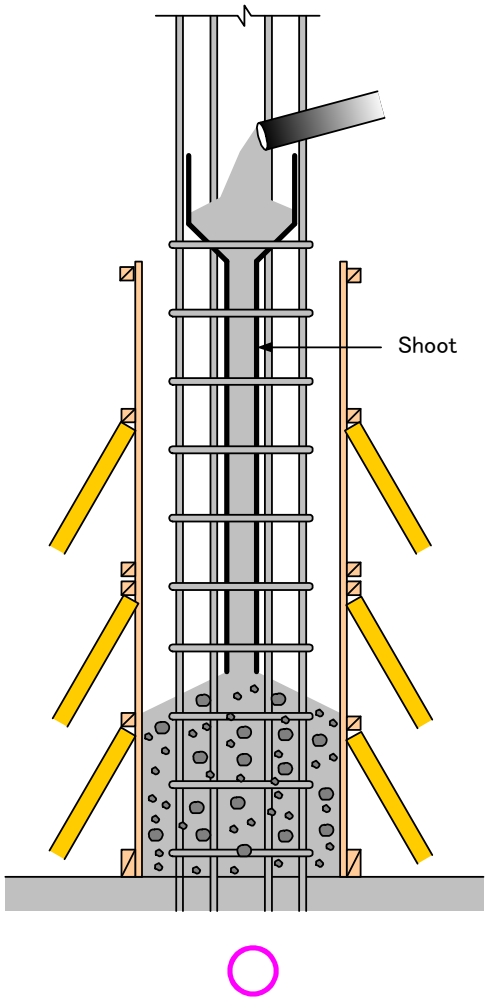
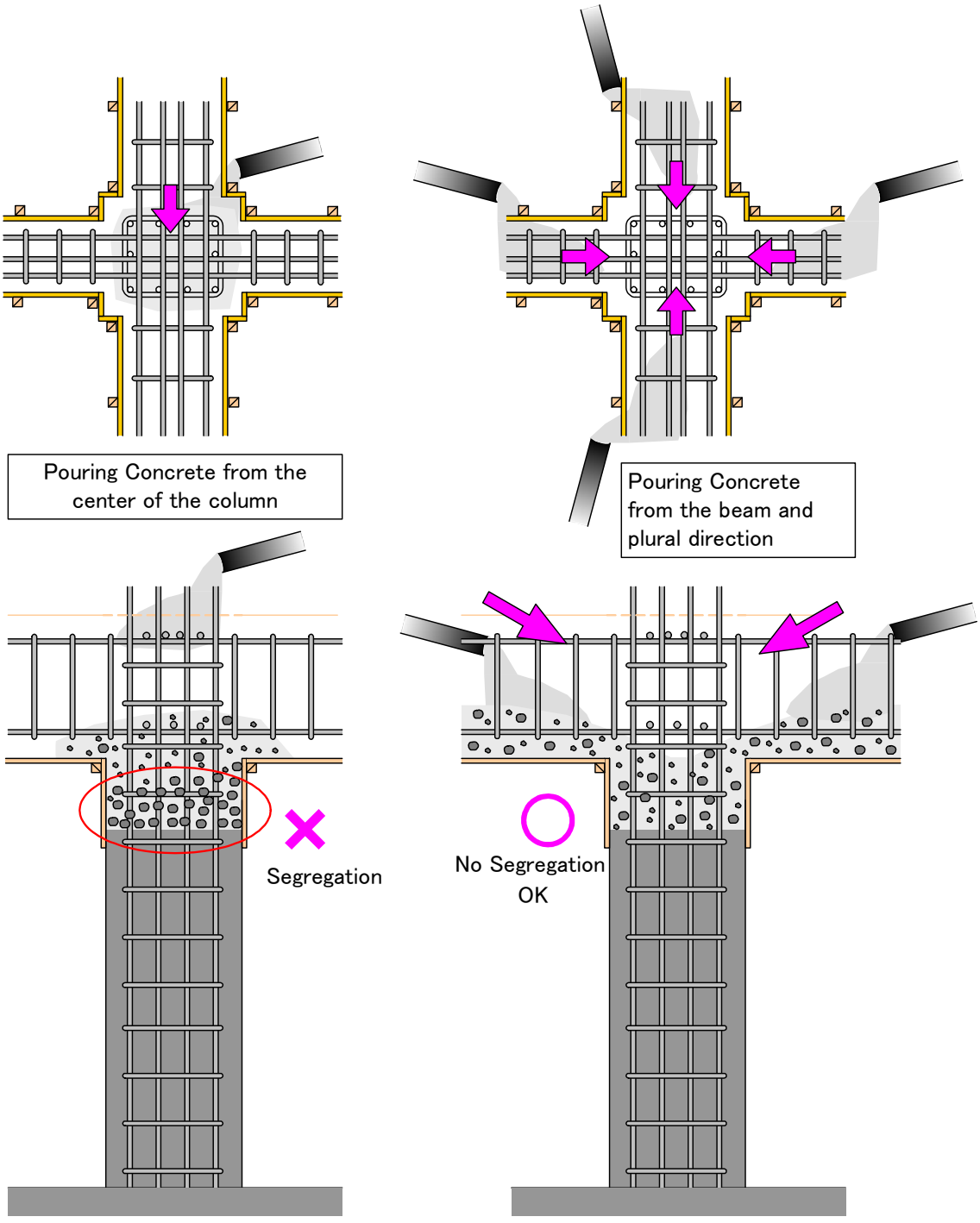


Fig-13: Steel shoot

Use the vertical shoot and pouring the concrete uniformly.

(2) The pouring concrete of the top of the column shall be discharged from the beams and plural direction, don't shoot the concrete from the center of the column where the reinforcing bars are crowded.



(3) The pouring concrete for long column (H=4.0m or 4.5m or more), shall use vertical shoot as shown Fig-13, or, make opening and collecting pocket at the center of the column as shown Fig-16, and discharge the concrete carefully, don't pour the concrete directory as shown Fig-14 and Fig-15 so that to avoid segregation at bottom of the column.

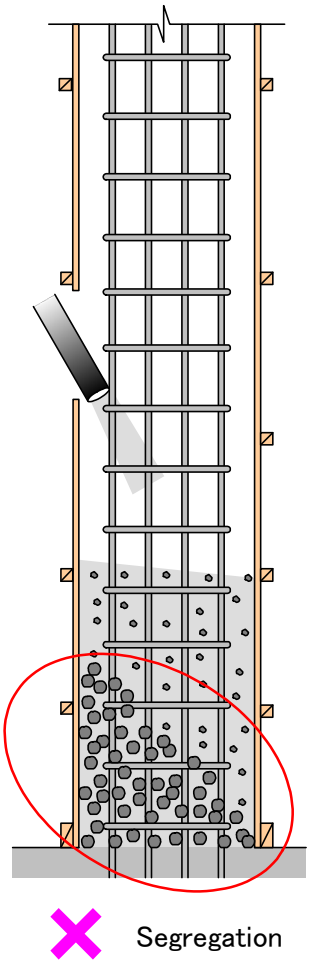


Fig-14 Direct pouring

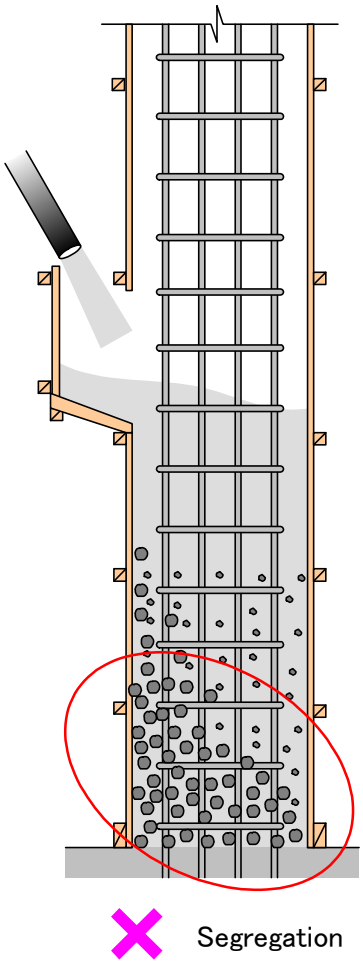


Fig-15 same as direct pouring

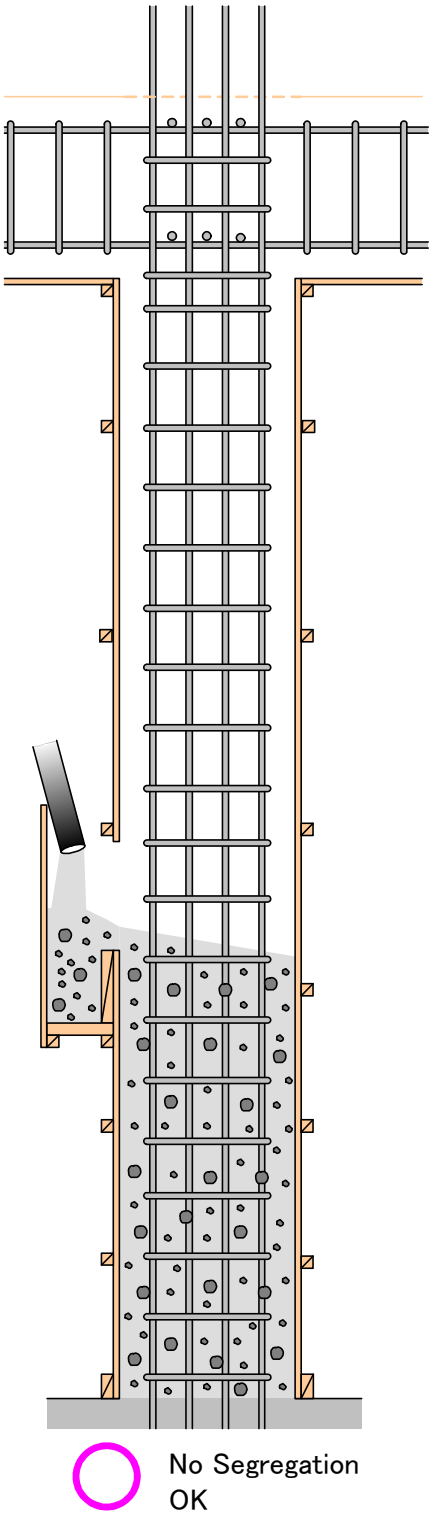


Fig-16 Correct pouring

(4) Influence of the segregation

- In the case of long column (H=4.0m or more), If pour the concrete directory from the top of the column, segregation will outbreak due to big size stone sink down and concentrate to the bottom of the column.
- The concrete strength become strong in proportion to the amount of the gravel, therefore, if segregation happens, the concrete strength of bottom part of the column become bigger than expected strength up to approximately 120%, and the concrete strength of top part of the column become smaller than expected strength up to approximately 80% as shown Fig-17.

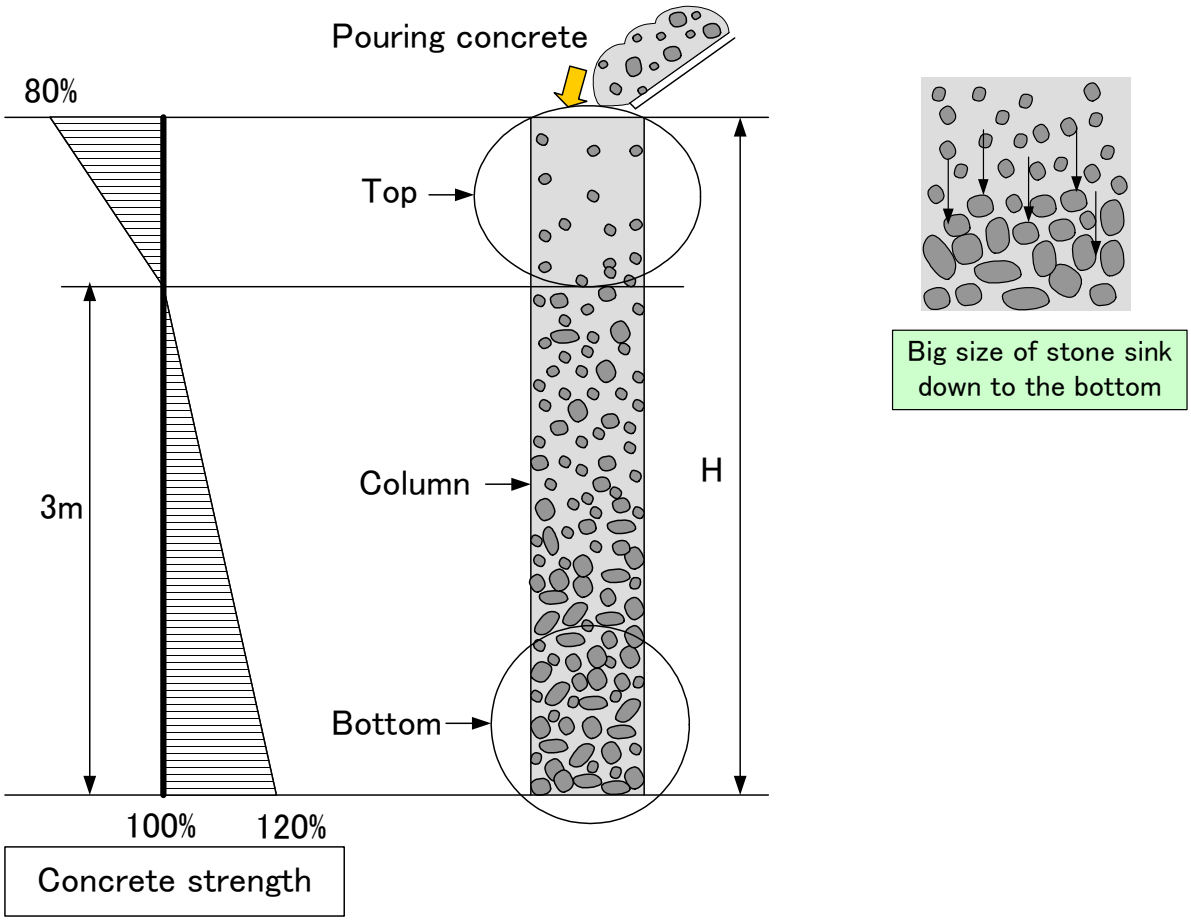
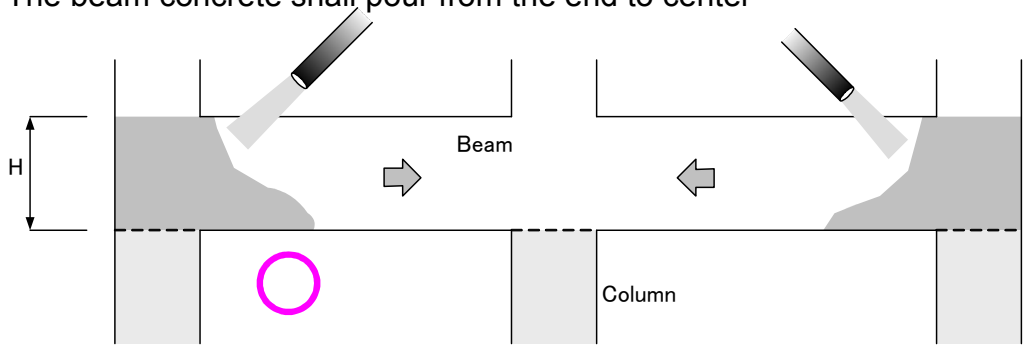


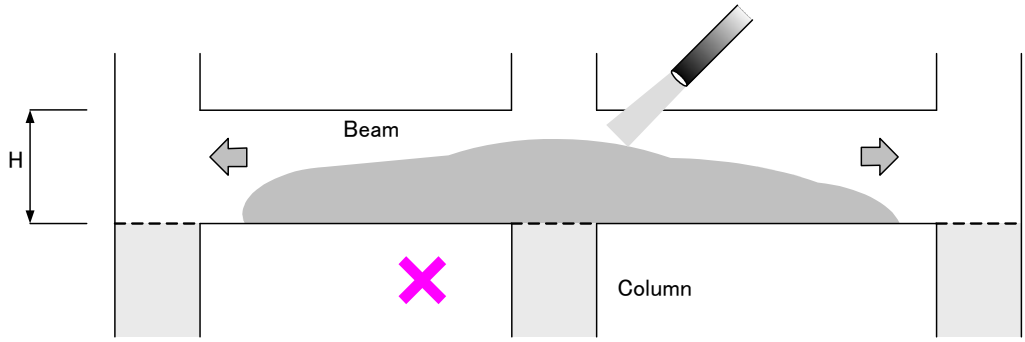
Fig-17: Reduce concrete strength due to Segregation

2-1-4. Pouring concrete for Beam

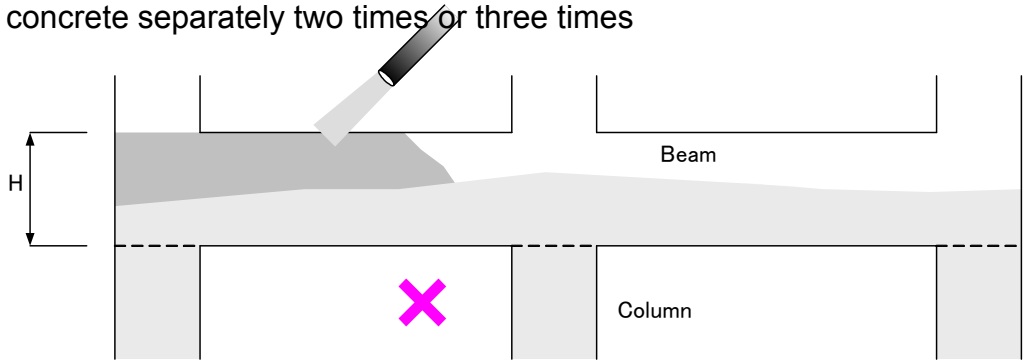
(1) The beam concrete shall pour from the end to center



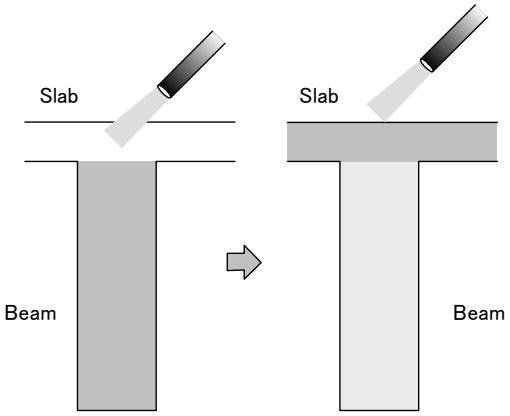
(2) Don't pour the concrete from the center to the end



(3) Concrete shall pour up to beam height (H) by one time, don't pour the concrete separately two times or three times



(4) In the case of deep beam, the concrete for slab shall pour after confirmation of the settlement of the fresh concrete of the beam



2-1-5. Pouring concrete for Slab

(1) Slab concrete shall pour from the far side as shown Fig-18, don't pour the concrete from near side as shown Fig-19.

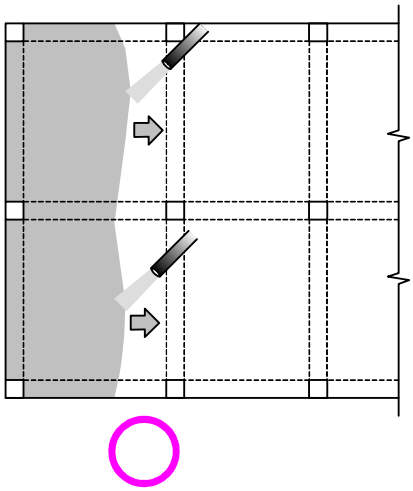


Fig-18: Pouring Concrete from the far side

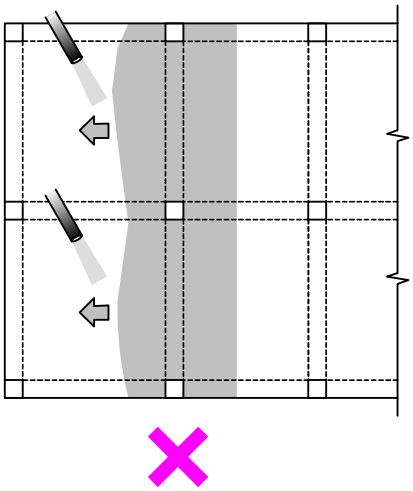


Fig-19: Pouring Concrete from the near side

(2) Slab concrete shall pour while moving back as shown Fig-20, don't pour the concrete while moving forward as shown Fig-21.

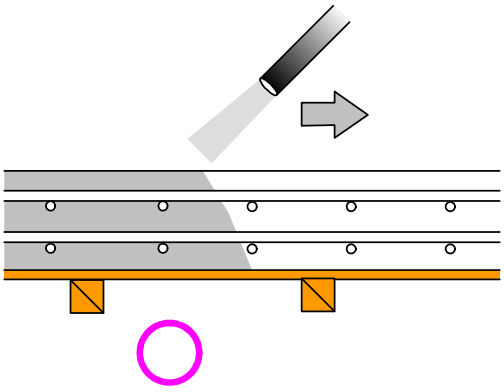


Fig-20: Pouring Concrete while moving back

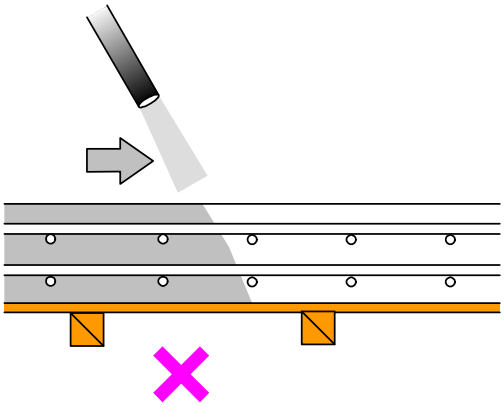


Fig-21: Pouring Concrete while moving forward

2-1-6. Construction joint

(1) Construction joint shall be horizontal or vertical and located near the center of the span for beams and floor slabs as shown Fig-22. Don't make construction joint near by column and Beam as shown Fig-23

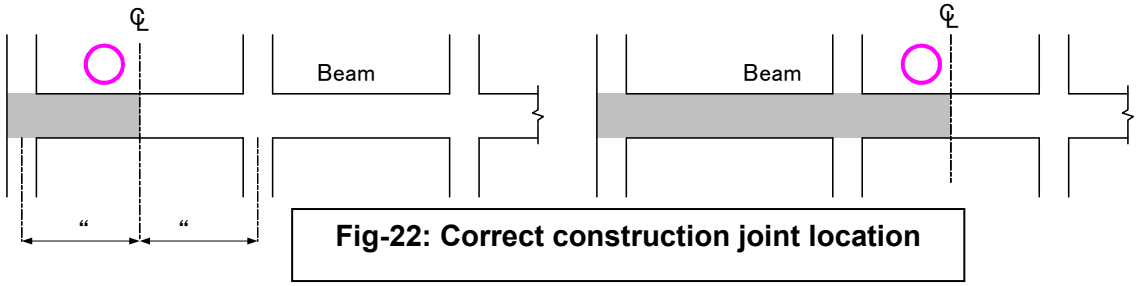


Fig-22: Correct construction joint location

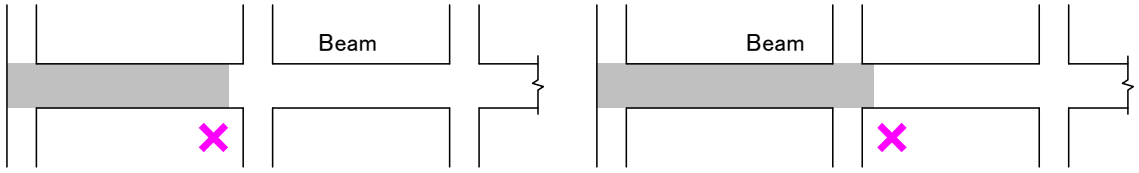


Fig-23: Incorrect construction joint location

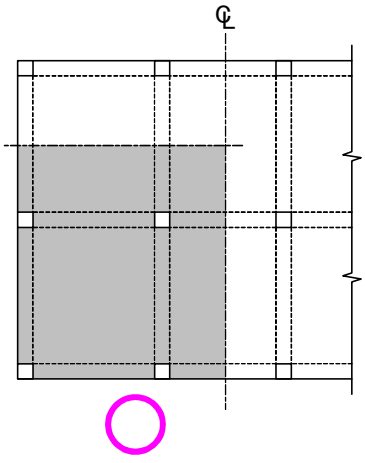


Fig-24: Correct construction joint location

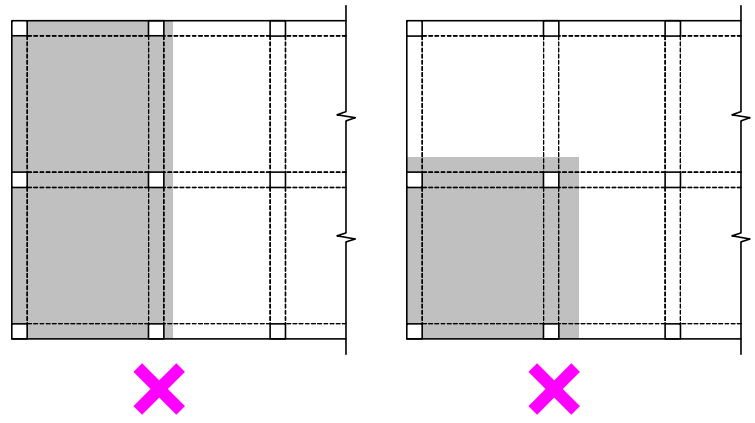


Fig-25: Incorrect construction joint location

(2) Partition plates shall be used for joints of successive pours such that mortar, cement paste will not leak out as shown Fig-***. Where the horizontal construction joint is on the outer surfaces, it shall be made straight using driving rulers. Don't pour the concrete without stopper as shown Fig-***.

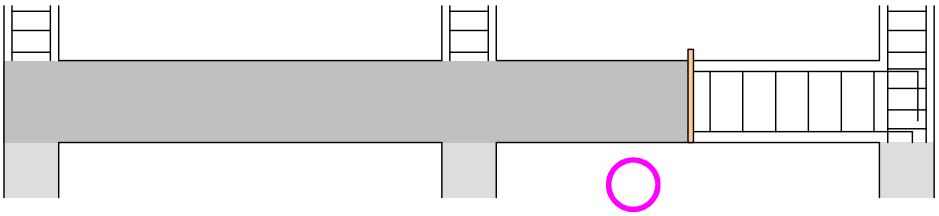


Fig-26: Appropriate location of the construction joint and stopper

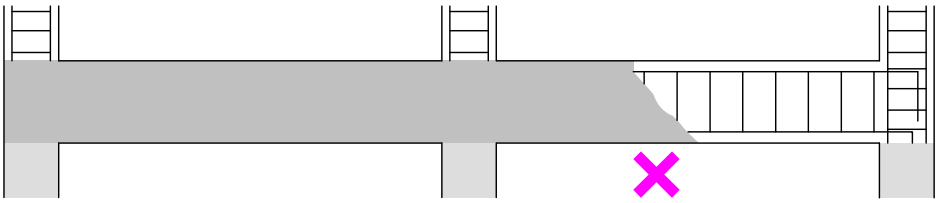


Fig-27: No concrete stopper for construction joint

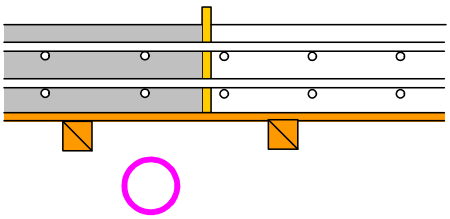


Fig-28: Correct concrete stopper

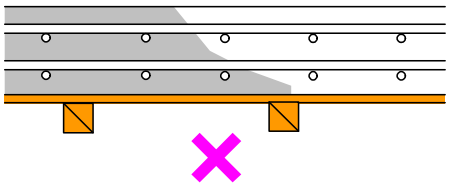


Fig-29: No concrete stopper

(3) In the case of column, the construction joint shall be horizontal or gentle curve as shown Fig-30. Don't make construction joint obliquely or make dent as shown Fig-31.

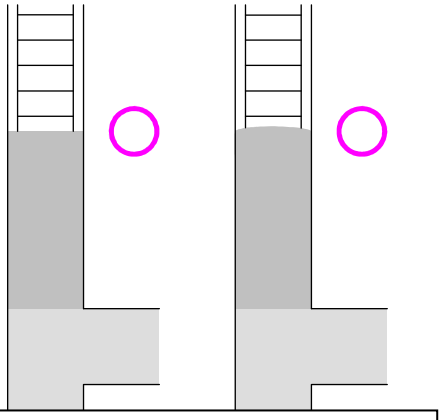


Fig-30: Correct construction joint

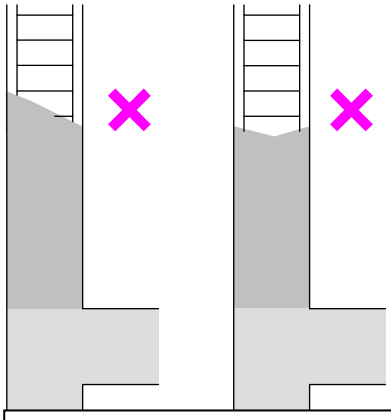


Fig-31: Incorrect construction joint

(4) Laitance and weak concrete shall be removed from the surface of construction joint to expose sound concrete.

1) Vertical or horizontal stopper shall be used for construction joint as shown Fig-32
2) Laitance and weak concrete shall be removed by tipping as shown Fig-33
3) Before pouring concrete, watering shall carry out to the construction joint as shown Fig-34.

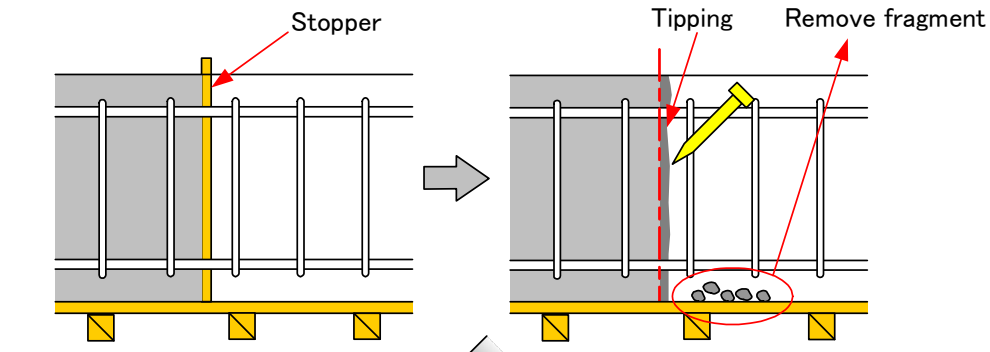


Fig-32: Stopper

Fig-33: Tipping

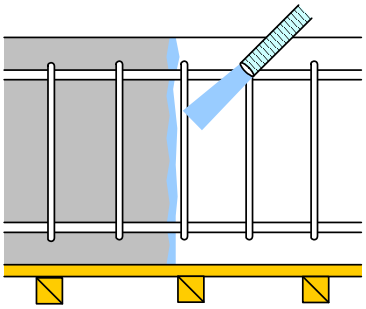


Fig-34: Watering

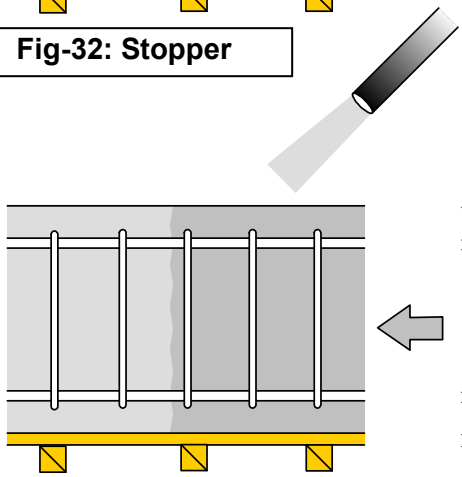


Fig-35: Pour Concrete

2-1-7. Vibrator

(1) Compaction and Vibrating shall use vibrator and/or compaction stick.

(2) Vibrator shall use vertically as shown Fig-36, don't use obliquely as shown Fig-37.

(3) Don't stirring the concrete by the Vibrator as Shown Fig-38.

(4) Spacing of Vibrating shall less than 60cm as shown Fig-36, and Vibrating time shall 5 to 10 seconds for one time and up to come up the cement paste on the surface of the fresh concrete.

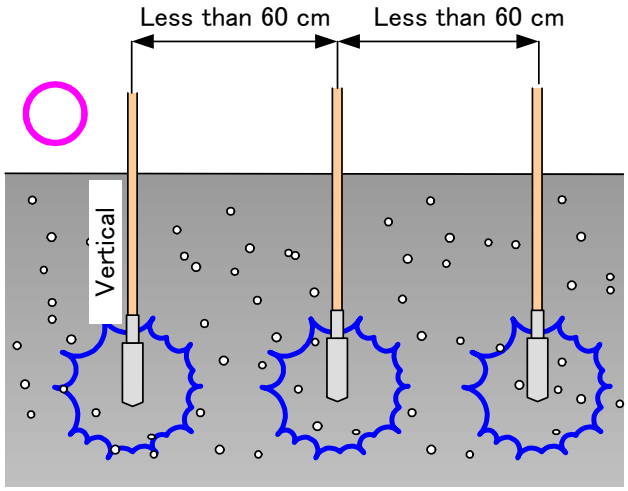


Fig-36: Correct use of vibrator

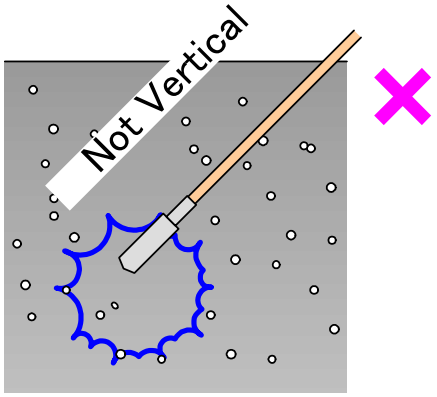


Fig-37: In correct use of vibrator

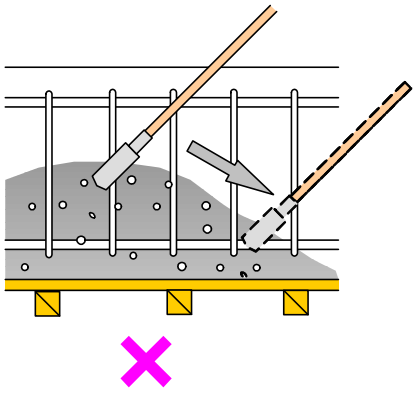


Fig-38: In correct use of vibrator

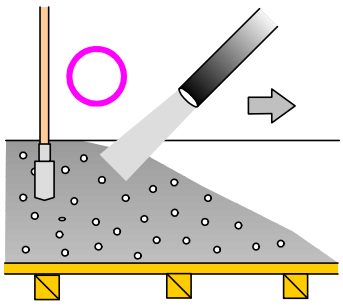


Fig-39: Correct use of vibrator

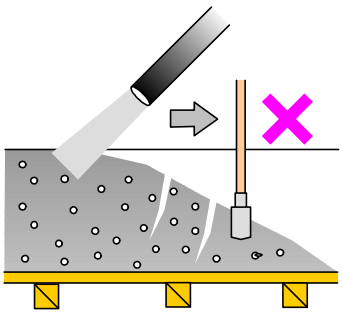


Fig-40: In correct use of vibrator

(5) Compaction and Vibrating shall be carefully done so that to filling concrete to every corner of the form and every re-bar as shown Fig-41.

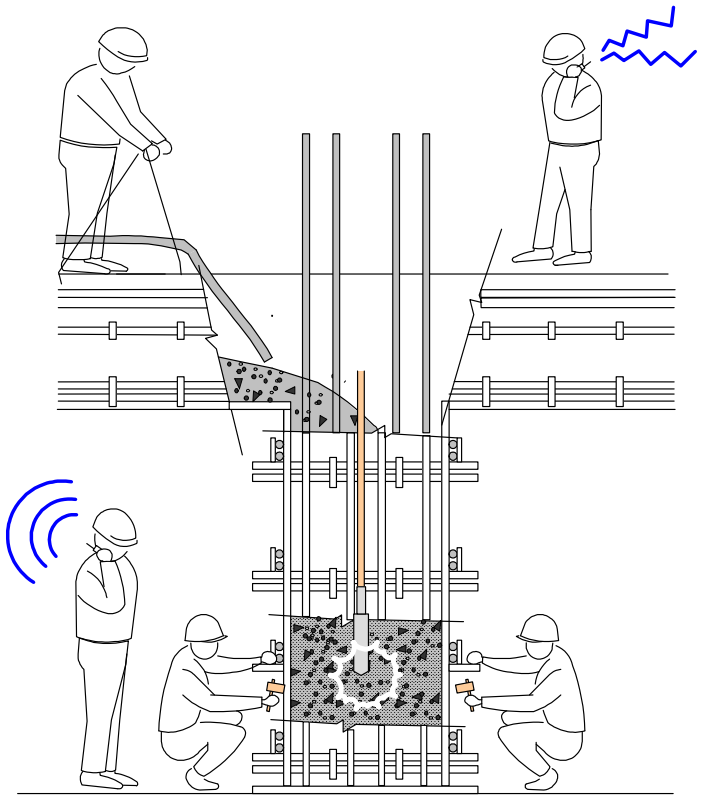


Fig-41: Correct concrete Pouring method

2-1-8. Honeycomb

Honeycomb will outbreak due to no vibrator, wrong way pouring work, leakage cement milk from the gap of poor form etc as shown Fig-42.

In the event that serious defect is found, approval for repair technique shall be sought from the Supervisor and the work shall be subject to inspection by the supervisor after repair.

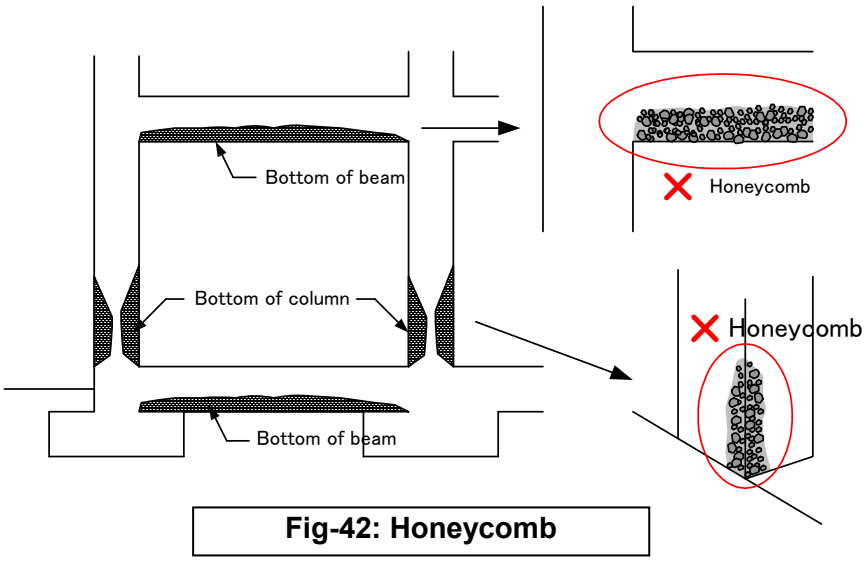


Fig-42: Honeycomb

Method of repair of the honeycomb

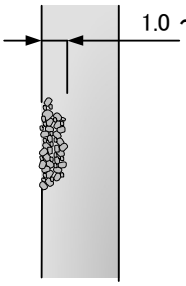


Fig-43, depth 1.0 to 3.0 cm, the gravel is exposed but not peeling off

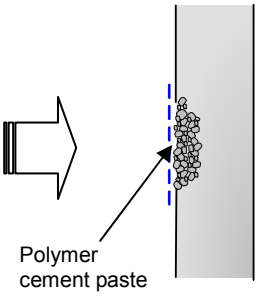


Fig-44, apply polymer cement paste on the concrete surface

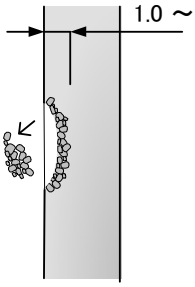


Fig-45, depth 1.0 to 3.0 cm, the gravel is exposed and peeling off.

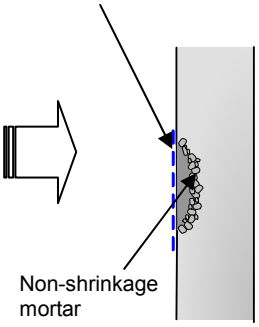


Fig-46,
Demolish surface, remove gravel, fill non-shrinkage mortar and apply polymer cement paste.

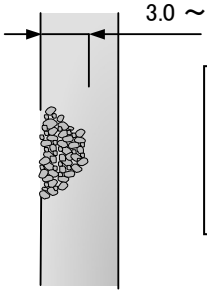


Fig-47, depth 3.0 to 10.0 cm, the re-bar is exposed

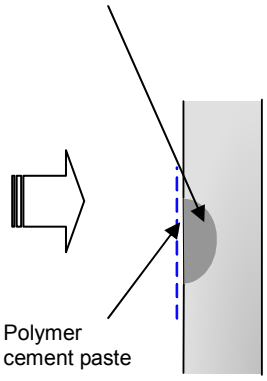


Fig-48,
Demolish surface, remove all gravel, fill non-shrinkage mortar and apply polymer cement paste.

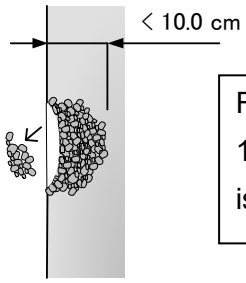


Fig-49, depth 3.0 to 10.0 cm, the re-bar is exposed

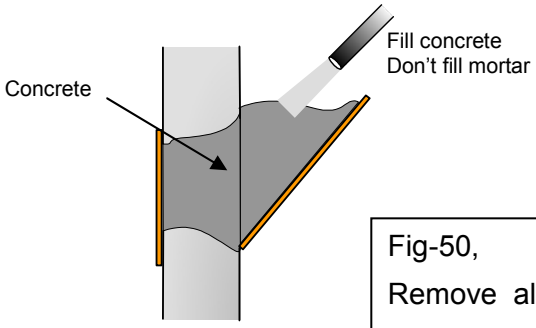
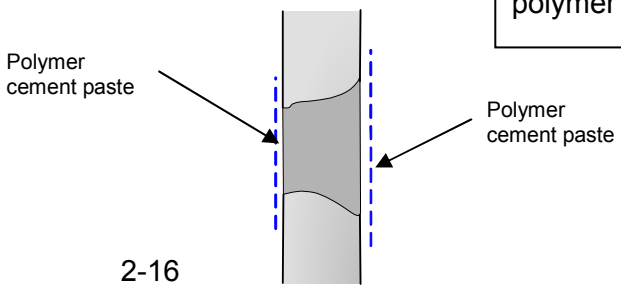
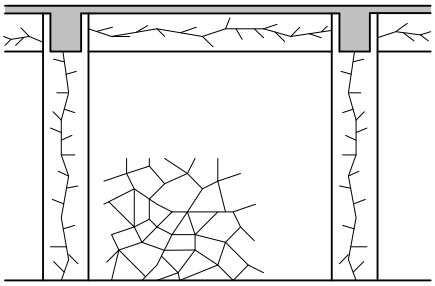
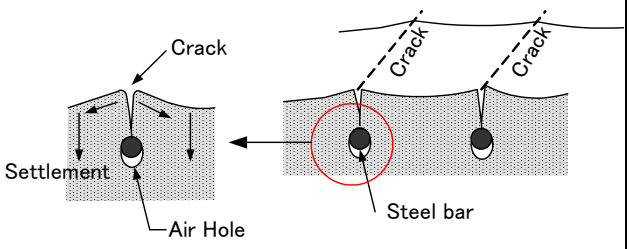


Fig-50,
Remove all gravel, fill the concrete, and apply polymer cement paste.



2-1-9. Crack

Almost of the crack outbreak by drying and shrinkage of the concrete due to evaporation of moisture when the process of solidification. Small crack has not give the serious problem to the structure, but, big crack reduce the durability and give serious damage to the structure.

<table>
<tr>
<td>(1) Crack due to Alkali- aggregate reaction
  </td>
<td>(2) Crack due to settlement
 
</td>
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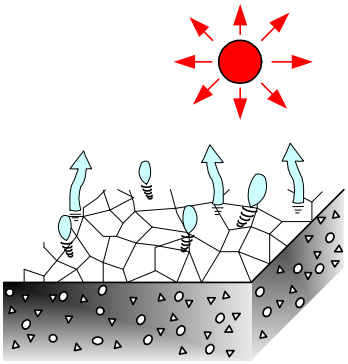
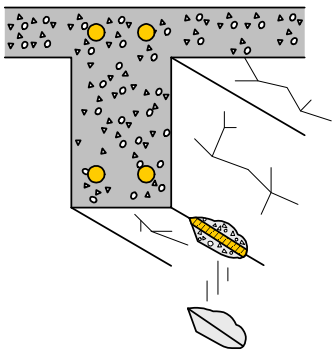
<tr>
<td>(3) Crack due to early evaporation moisture
  </td>
<td>(4) Crack due to lack of concrete cover thickness
  </td>
</tr>
</table>

(1) Crack due to Alkali- aggregate reaction

Alkali- aggregate reaction outbreak netlike or tortoise crack

(2) Crack due to settlement of fresh concrete.

Settlement of fresh concrete due to leakage of cement paste, settlement and/or deformation of form and/or support, air hole by bleeding outbreak crack along the steel bar just after one (1) to six (6) hours from pouring concrete.

(3) Crack due to early evaporation moisture caused by insufficient moisture curing for fresh concrete.

(4) Crack due to lack of concrete cover thickness.

If concrete cover is small, the crack outbreak along the main bar and concrete peel off

(5) As the countermeasure to prevent the crack, to know the cause is very important. The crack can prevent and/or reduce by correct knowledge of concrete work.

(6) The following table shows main cause and countermeasure for the crack due to drying shrinkage.

Period	Cause	Countermeasure
Up to 7 days	• Early solidification • Contain too much muddy substance • Sedimentation • Speedy pouring • Deformation and/or settlement of form and/or support • Early loading • Dry out in a short period	• Watering to form before pouring concrete • Adequate concrete cover • Insert spacer and supporter • Fix bar tightly so that to prevent moving when poring concrete. • Don't leave the materials on the ground directly. • Vibratory carefully • Poring moderately • Strong form and support • No gap • Keep adequate period for supporter. • Keep moisture curing more than 7 days or more • No loading after 7 days at least. • etc
Up to 28 days	• Drying and shrinkage • Lack of moisture curing • Early take out support • Loading and vibration	
After 28 days	• Drying and shrinkage • Poor concrete strength • Corrosion of steel bar • Lack of concrete cover • Lack of amount of steel bar • Concentrate stress • Over load • Temperature stress	

(7) Desirable character of the aggregate for prevent and/or reduce crack for Alkali-aggregate reaction

Material	Character	Description
Quality	• Hard stone • Big elastic module	Limestone lock, Andesite, Granit, Basalt, Slate etc
Impurity substance	• No muddy content	• Decantation test Less than 1.0% for coarse aggregate and less than 3.0% for fine aggregate
	• No chloride	• Salty content shall less than 0.1%
Water absorption	• Small absorption	Less than 3.0% for coarse aggregate and less than 3.5% for fine aggregate, less than 2.0% for gravel stone
Grain diameter	• Big	
Solid content	• Big	• Around 55% to 65 %

2-2 Form works

2-2-1 Material

- Formwork shall be made of timber, plywood, plastic coated plywood or steel plate.
- Surface of formwork shall be clean.
- Apply coating material (liquid) to formwork.
- Concrete will be fine surface by applying coating liquid. And it will be possible to use plywood forms more two or three times.

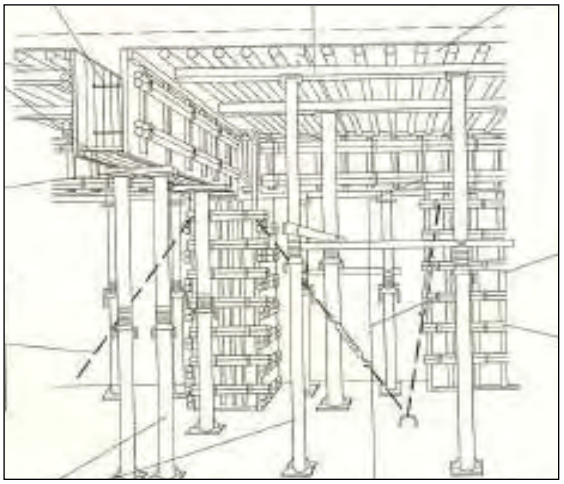
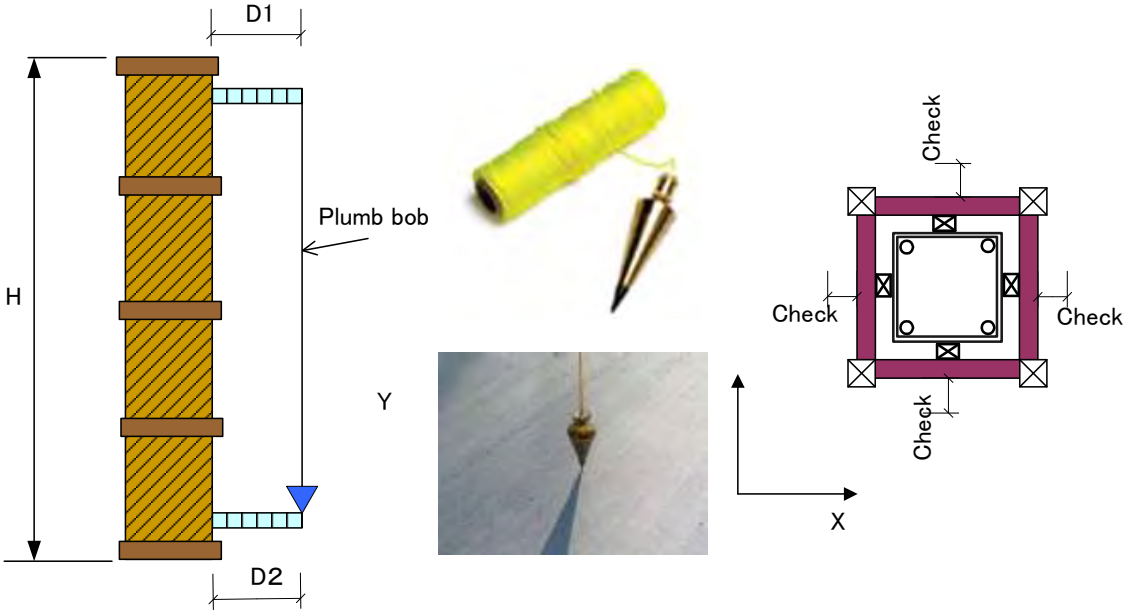


Fig-51 Form work

- Formwork shall be stocked with weather protection.
- Reuse of formworks to another works shall be less than 2 times because of quality.

2-2-2 Vertical line of the column



◆

Fig-52 Column Vertical Check

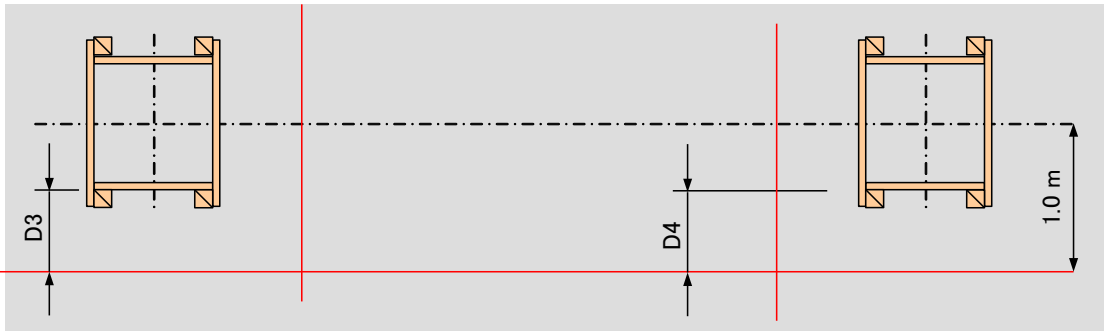
Check distance D1 and D2 for every direction, vertical tolerance (=D1-D2) shall be as following Table-10.

Table-10 Tolerance for Vertical elements (by ACI)

Column total height	Column Position	Vertical Tolerance (D1-D2)
Column (H<30m)	Corner column	Less than 13mm
	Other column	Less than 25mm
Column (H>30m)	Corner column	Less than H/2000 and 76mm
	Other column	Less than H/1000 and 152mm

◆ Before fixing the form, the vertical line shall be inspected, if inspection value is over than tolerance, the form shall be removed and rebuilt again.

2-2-3 Horizontal Alignment



◆ Check distance D3 and D4 for every direction, horizontal tolerance (=D3-D4) shall be as following Table-11.

Table-11 Tolerance for horizontal elements (by ACI)

Name of the element	Horizontal tolerance (D3-D4)
Girder, Beam, Slab etc	Less than 25mm

◆ Before fixing the form, the horizontal line shall be inspected, if inspection value is over than tolerance, the form shall be removed and rebuilt again.

2-2-4 Inside measurement

◆ Check inside dimension

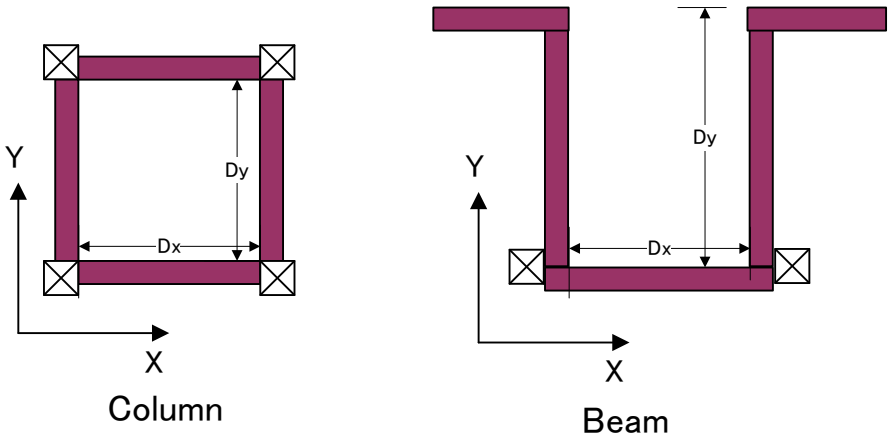
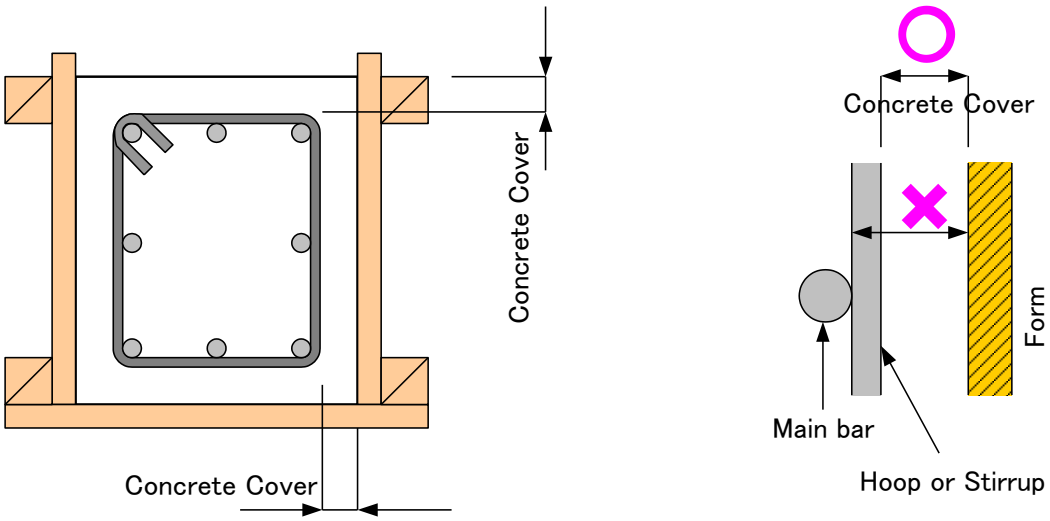


Table-12 Standard tolerances for cross-sectional dimensions (By ACI)

Element	Design dimension	Tolerance of Dx and Dy
Column, Beam Foundation, and Slab	Less than 30cm	+10mm and -6.0mm
	Over 30cm and less than 90cm	+13mm and -10.0mm
	Over 90cm	+25mm and -19.0mm

◆ Before fixing the form, the inside dimension shall be inspected, if inspection value is over than tolerance, the form shall be removed and rebuilt again.

2-2-5 Concrete cover



◆ Check concrete cover

Unless otherwise specified in the design drawing, the minimum concrete cover shall be as following Table-14.

Table-14 Minimum cover thickness

Type of structural elements			Minimum of Protective Concrete Cover thickness
Elements not in contact with soil	Slabs and Walls	With finishing	20mm
		No finishing	30mm
	Columns and Beams	With finishing	40mm
		No finishing	40mm
Elements contact with soil	Columns, Beams, Floors, Slabs and Walls		50mm
	Foundation and Retaining Wall		70mm

◆ Concrete cover shall be distance between the surface of the hoop or stirrup and inside of the form as shown Fig-***.

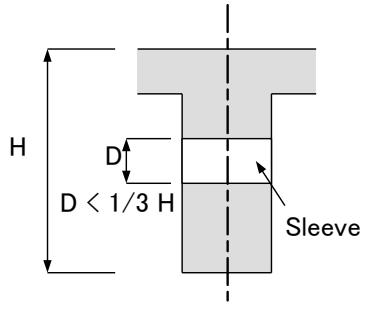
◆ Before fixing the form, the concrete cover shall be inspected, if inspection value is over than minimum thickness, the form shall be removed and rebuilt again.

2-2-6 Position of the sleeves

◆ The position of sleeve hole shall be zone of H/2 as shown Fig-53, don't make sleeve hole out of zone of H/2 as shown Fig-54.

◆ Diameter of sleeve shall be less than 1/3H and minimum distance L shall bigger than H, allowable zone of sleeve hole is within 1/2H.

.



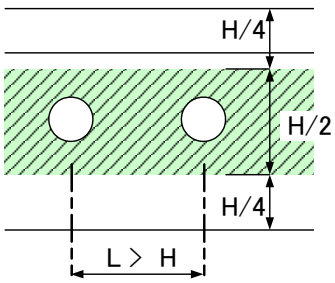


Fig-53: Correct Position

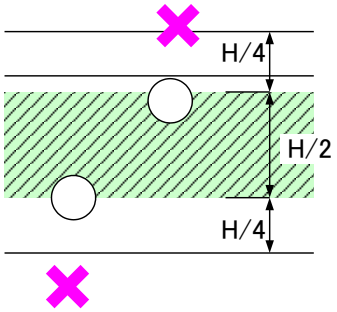


Fig-54: Incorrect Position

2-2-7 Assembling

- Don't oversights gap of the form; cement milk must be leak to outside.
- Every connection of the form shall be inspected, if the gap is discovered as shown Fig-55 and Fig-56, the form shall be removed and rebuilt again. Otherwise serious problem will be outbreak as shown Fig-58 and Fig-59.

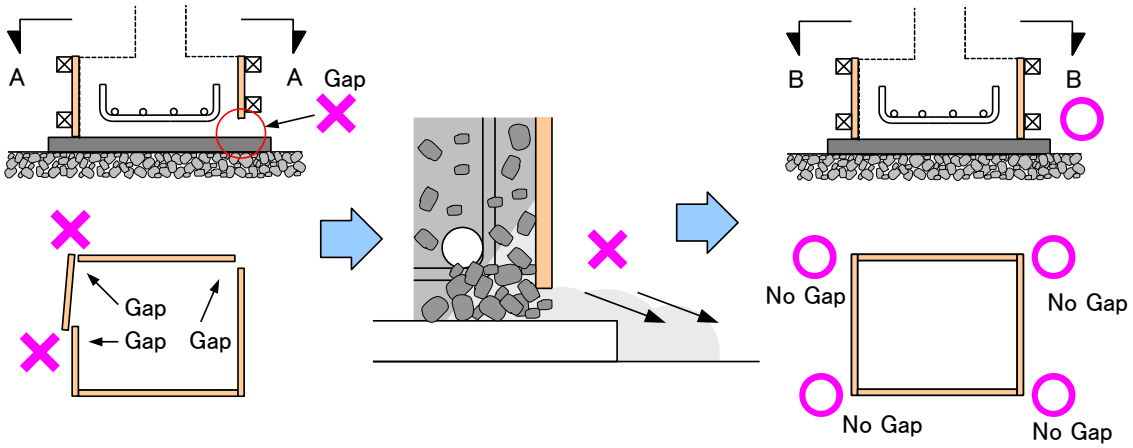


Fig-55: Incorrect form

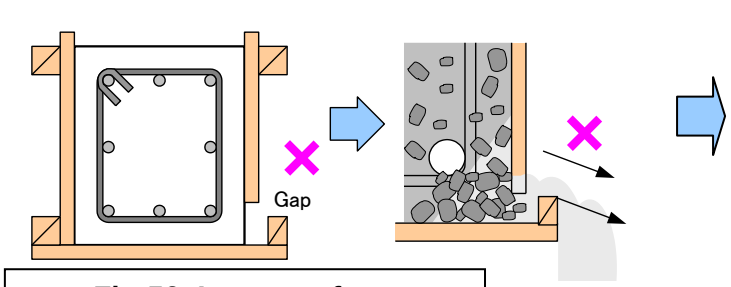


Fig-56: Incorrect form

Fig-57: Honeycomb

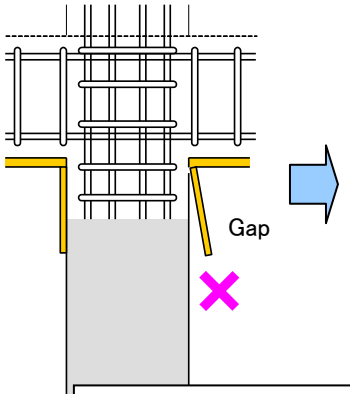


Fig-58: Incorrect form

Fig-59: Serious problem outbreak

2-2-8 Support

(1) Supports shall not be stood directly on the ground as shown Fig-60.

(2) Supports shall be stood on the strong base as shown Fig-61 and/or concrete basement as shown Fig-62.

(3) Supports shall be fixed firmly and shall not be moved vertically and horizontally.

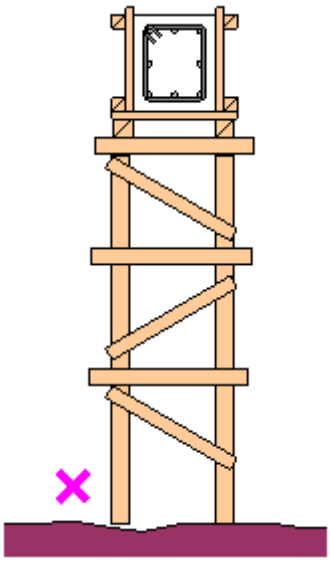


Fig-60: on the ground

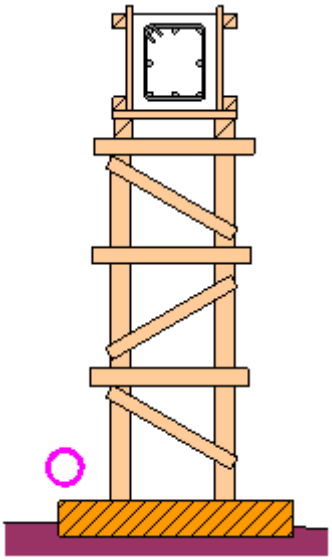


Fig-61: on the base

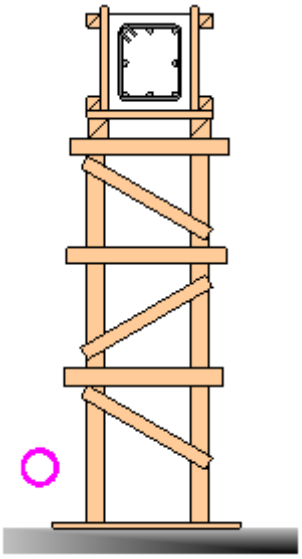


Fig-62: on the concrete

2-2-9 Removal of form

(1) Form shall not be removed until the minimum standing times was elapsed.

(2) Minimum standing time shall be determined from Table-15 and Table-16 in terms of the age or compression strength of concrete.

(3) Supports (or columns) supporting a cantilever beam, canopy, beam with large span, large-size floor slab or an extremely large working load shall be kept for longer periods as required.

(4) Support shall not be replaced. Sheathing boards below floor slabs and beams shall as general rule be removed after taking out the supports.

Table-15 Minimum standing time for sheathing boards

Kind of the cement	Normal Portland cement
Based on age of Concrete (days)	3 days
Based on compression strength of Concrete	Until compression strength exceeds 5 N/mm^2

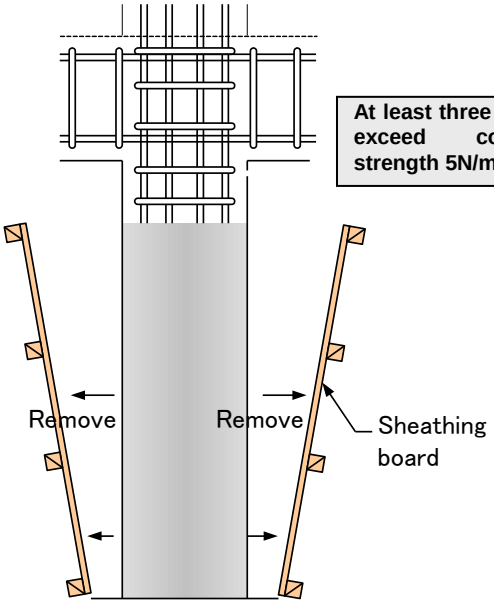


Fig-63: Column

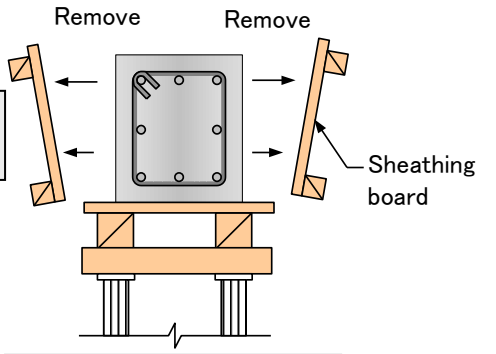


Fig-64: Beam

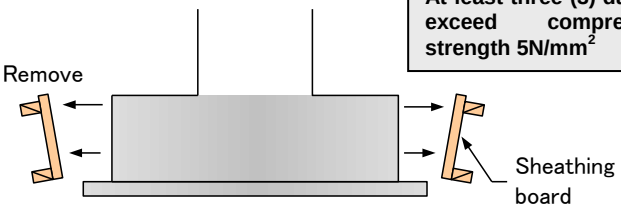


Fig-65: Foundation

Table-16 Minimum standing time for supports

Kind of the cement	Normal Portland cement	
Position	Under floor slab	Under beam
Based on age of Concrete (days)	17 days	28 days
Based on compression strength of Concrete	Until compression strength is over 85% of design strength or exceeds 12 N/mm^2, and load and external force during work was verified to be safe by structural calculation.	Until compression strength is over design strength or exceeds 12 N/mm^2, and load and external force during work was verified to be safe by structural calculation.

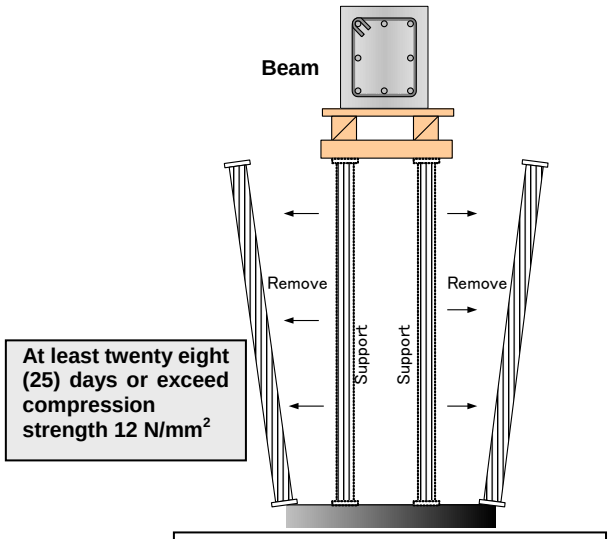


Fig-66: Column support

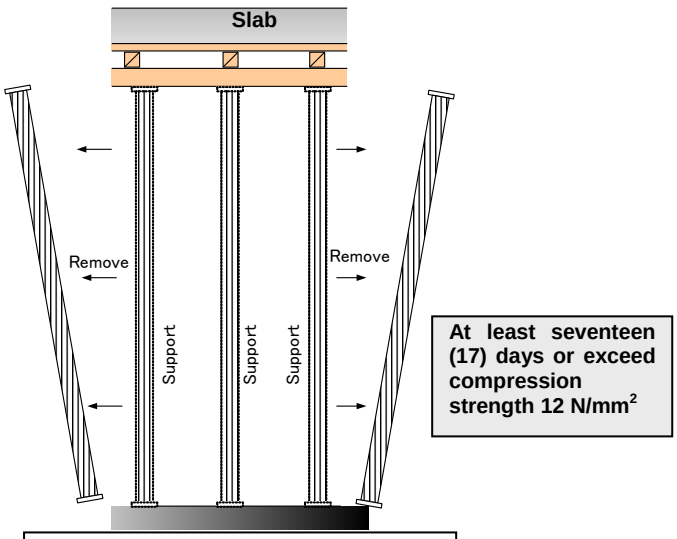
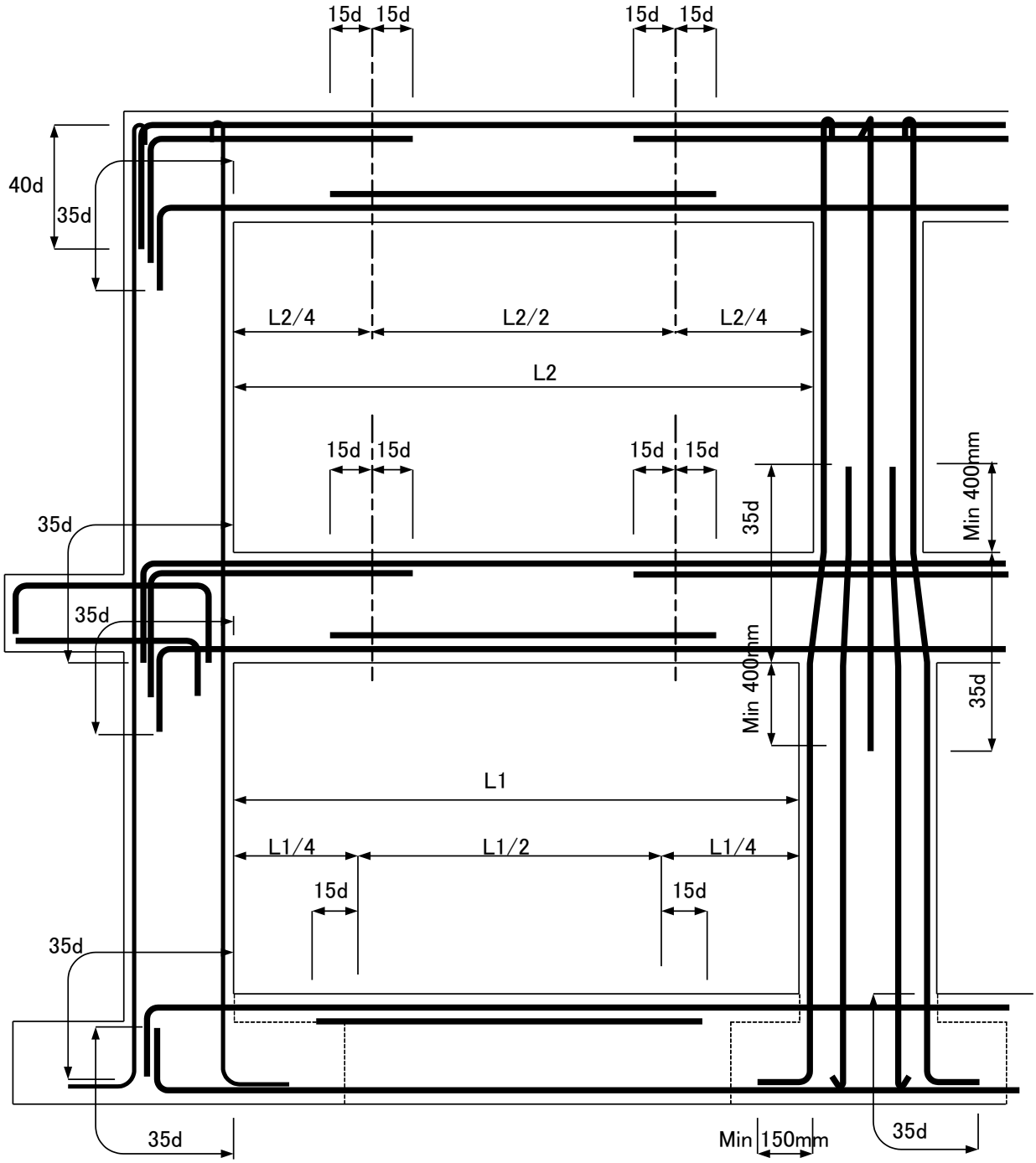


Fig-67: Beam support

2-3 Steel bar work

2-3-1. Standard bar arrangement

(1) Main frame



Note: d means diameter of steel bar

Fig-70 Standard bar arrangement

(2) Standard hoop arrangement and Anchor of small beam and slab

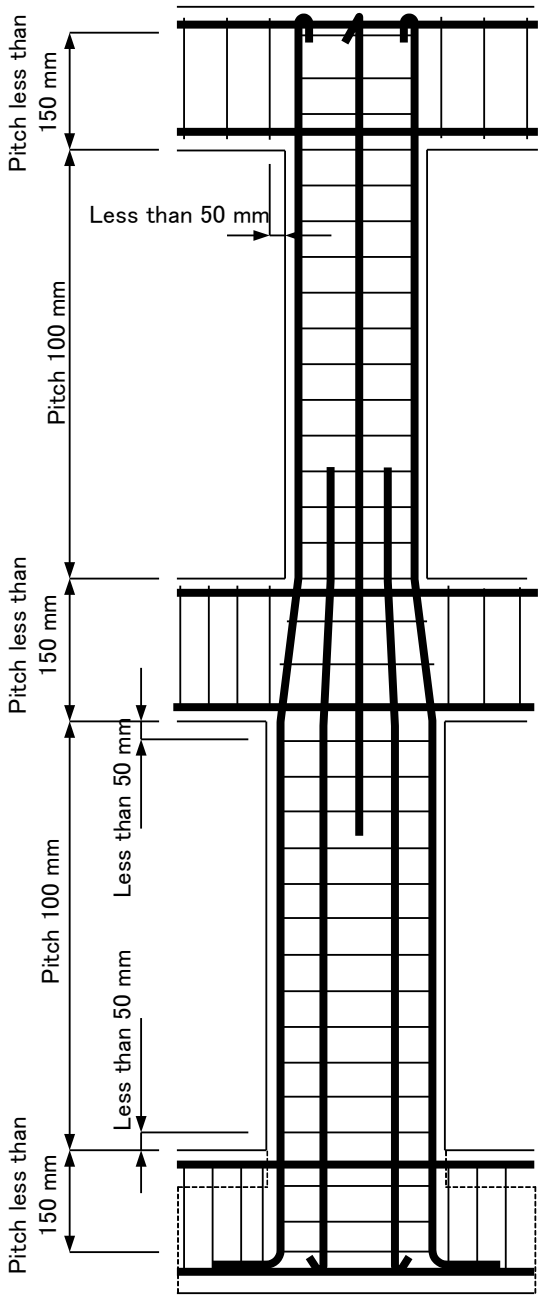


Fig-71 Hoop arrangement

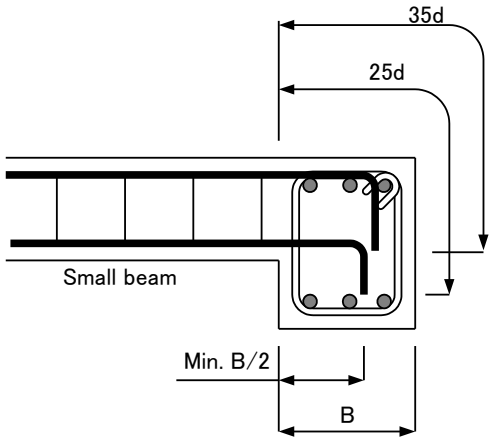


Fig-72
Anchor beam to beam

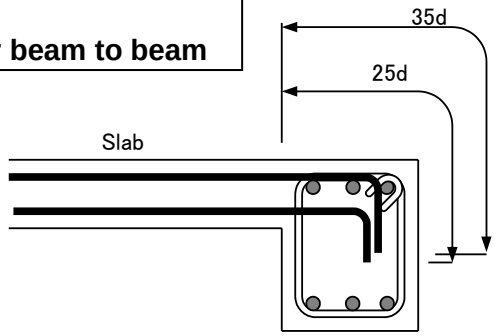


Fig-73 Anchor slab to beam

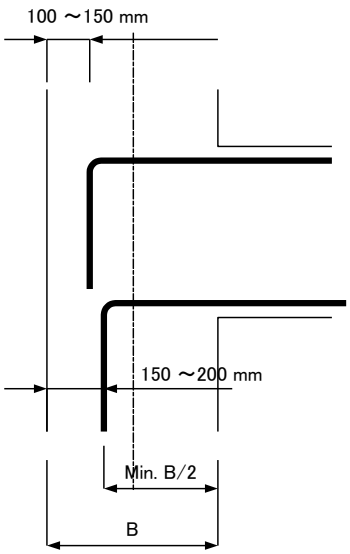


Fig-74 Anchor position of main bar

2-3-2. Tolerance deformation of bar arrangement

(1) Main bar

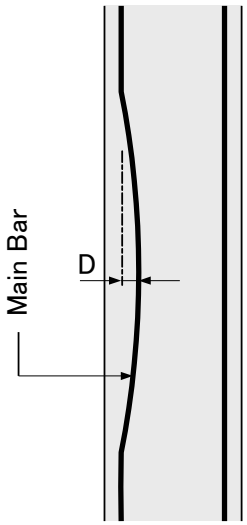


Fig-75: Column

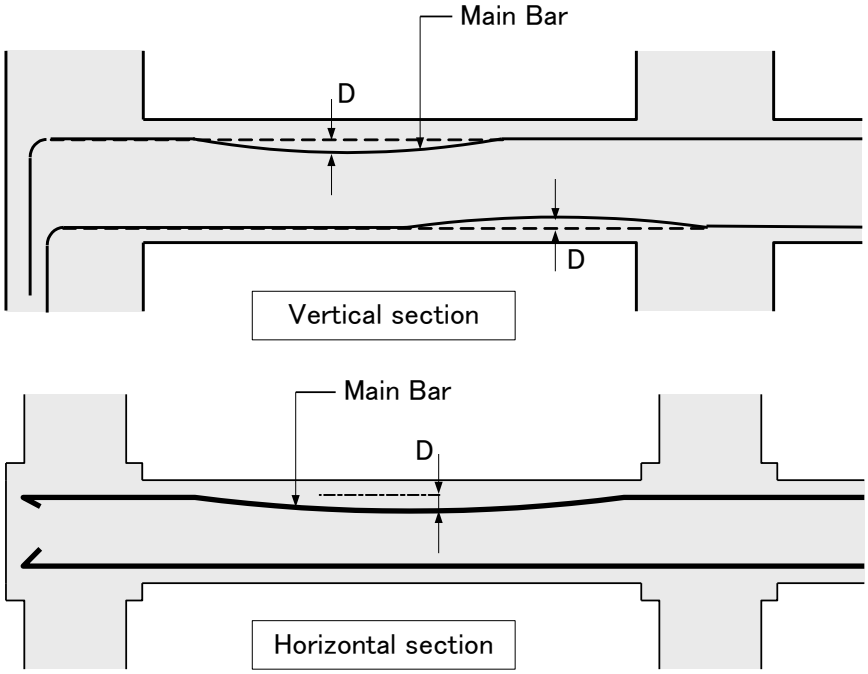


Fig-76: Beam

Note: Deformation of main bar D shall less than 1.0 cm

(2) Hoop and Stirrup

X means spacing specified by drawing, D shall less than 1.0cm, X1 and X2 shall less than X + 1.0cm, X3 shall less than X/2.

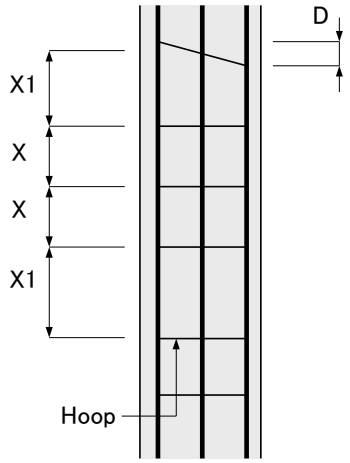


Fig-77: Column

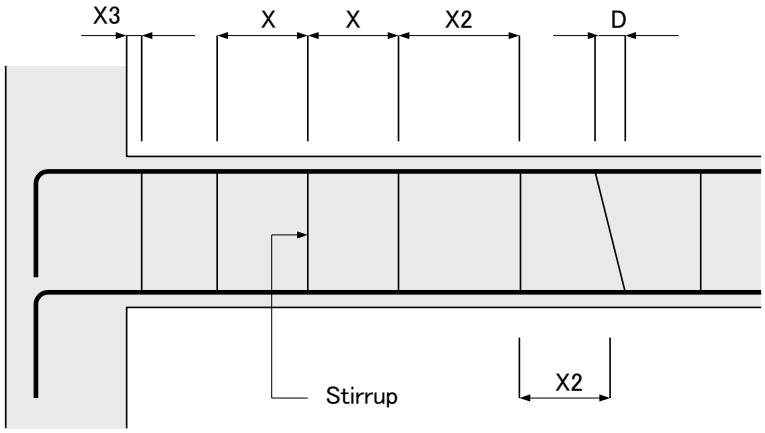


Fig-78: Beam

2-3-3. **Bar lapping**

(1) Location of the bar lapping shall be as Fig-80 so that to avoid the location where occur big tension force due to seismic as shown Fig-79.

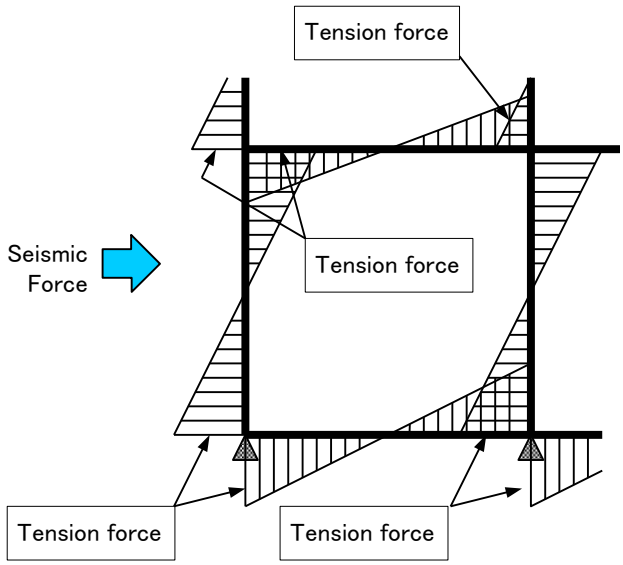


Fig-79: Typical Bending moment diagram

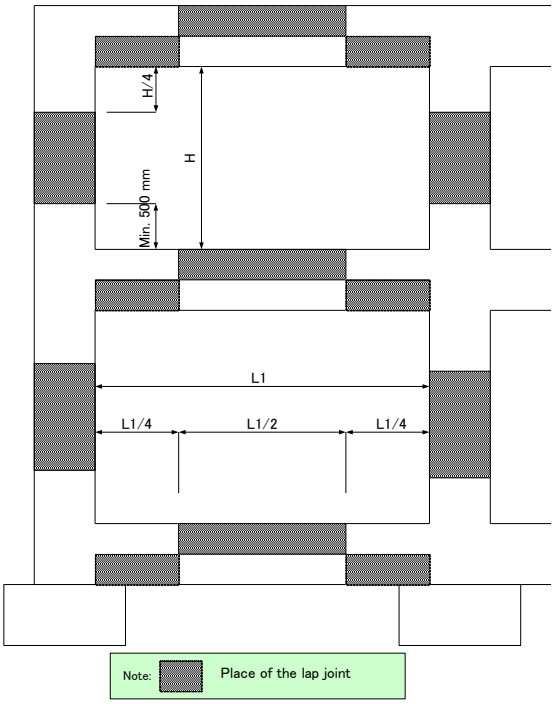


Fig-80: Lap zone

(2) Lap length and/or Anchor length shall be more than following table-20.

Table-20 Minimum Lap splice and Anchorage length

Type of Bar	Concrete Compressive Strength (N/mm^2)	Bar Size	Without Hook				With Hook			
			L1 (mm)	L2 (mm)	L3		L1 (mm)	L2 (mm)	L3	
					Small Beam (mm)	Slab (mm)			Small Beam (mm)	Slab (mm)
BJTD30 (SD295A) (SD295B) (SD345) -	21-27	D10	400	350	250	150	300	250	150	
		D13	520	455	325	150	390	325	195	
		D16	640	560	400	160	480	400	240	
		D19	760	665	475	190	570	475	285	
		D22	880	770	550	220	660	550	330	
		D25	1000	875	625	250	750	625	375	

(3) Location of neighboring bar lapping shall be as shown Fig-81and Fig-82.

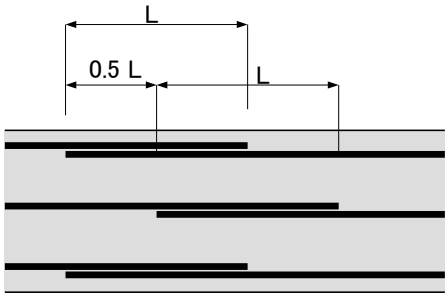


Fig-81: Correct lapping

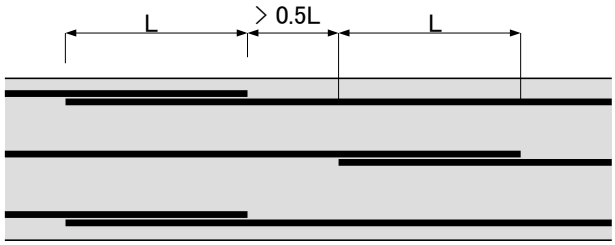


Fig-82: Correct lapping

(4) Don't make lap joint at the same location as shown Fig-83 and Fig-84.
In case of lap joint at same location, the crack liable to outbreak as shown Fig-85

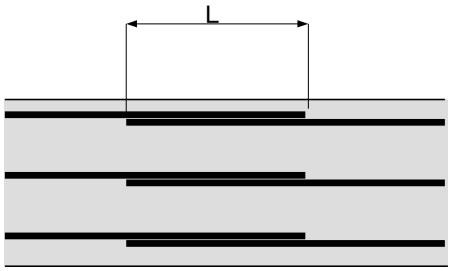


Fig-83: incorrect lapping

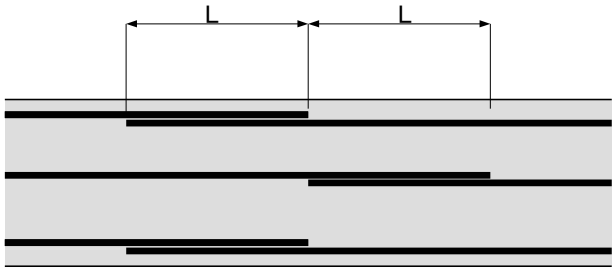


Fig-84: incorrect lapping

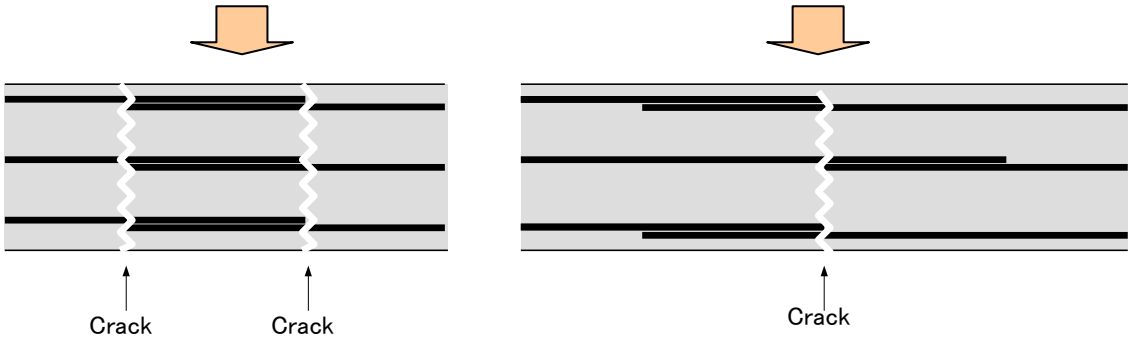


Fig-85: Crack due to incorrect joint

(5) Lap location of the column

1) Lap location of the column shall be as shown Fig-86.
2) Don't make lap joint as shown Fig-87.

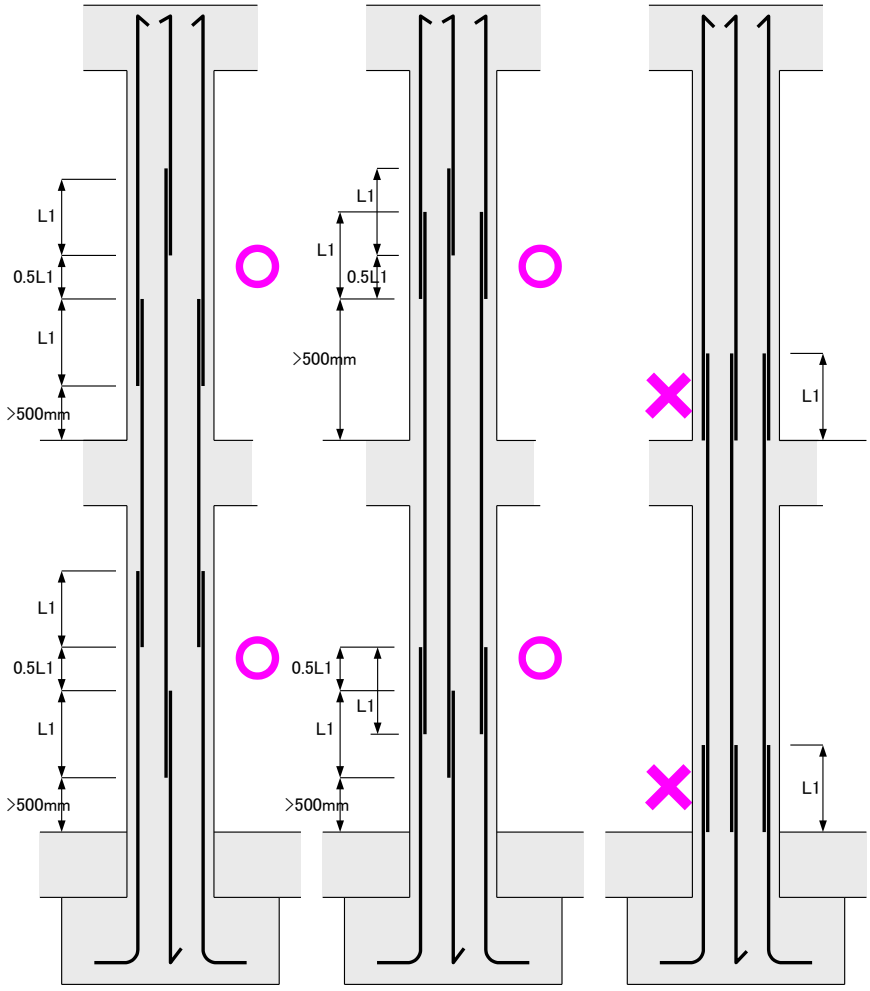


Fig-86: Correct position of lap

Fig-87: Incorrect position of lap

Fig-88:Destruction column and Beam

Fig-89: Lap at bottom of column

2-3-4. **Bar anchor**

(1) Bar anchor length and shall conform to Fig-70 and Table-20

(2) Main bar of the column shall be anchored up to zone exceed H/2 of the footing as shown Fig-91, if anchor as shown Fig-92, cracks will be occurred as shown Fig-93.

Fig-90: Typical anchor image

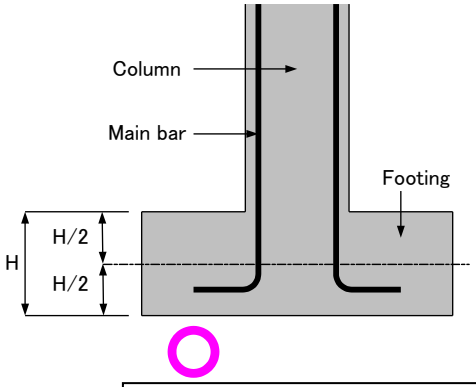


Fig-91: Correct anchor

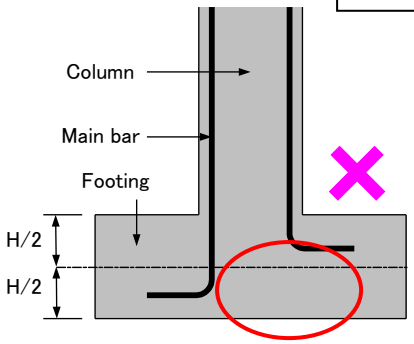


Fig-92: Incorrect anchor

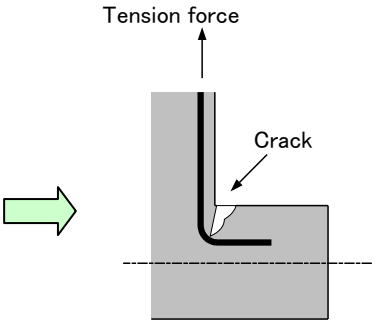


Fig-93: Outbreak crack

(3) Main bar of the beam shall be anchored into the column up to zone of exceed B/2 as shown Fig-94

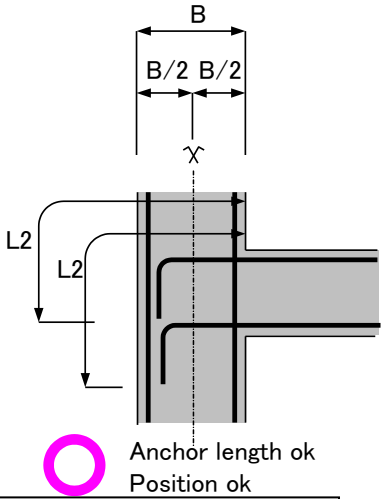


Fig-94: Correct anchor

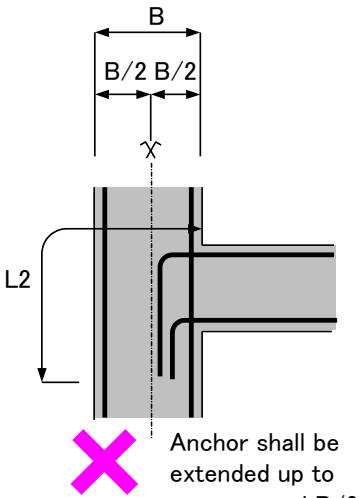


Fig-95: Incorrect anchor

2-3-5. Bar arrangement for difference dimension

(1) In the case of small difference dimension of the column (slope is less than 1 to 6) as shown Fig-96, the main bar of the column shall be bent as slope

(2) In the case of the big difference dimension of the column (slope is bigger than1 to 6) as shown Fig-97, the main bar of the column shall not be bent

(3) Same manner shall be applied to the bar arrangement of the beam

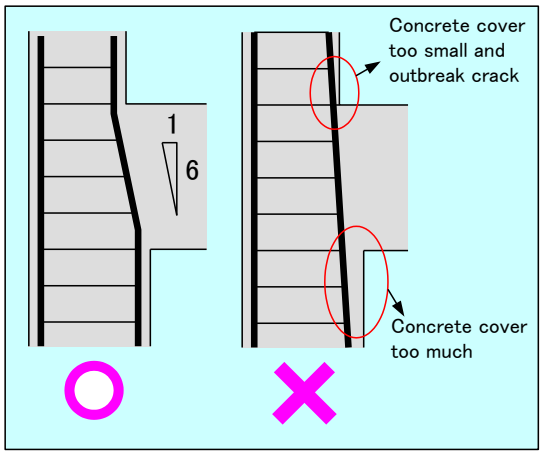


Fig-96: Small difference

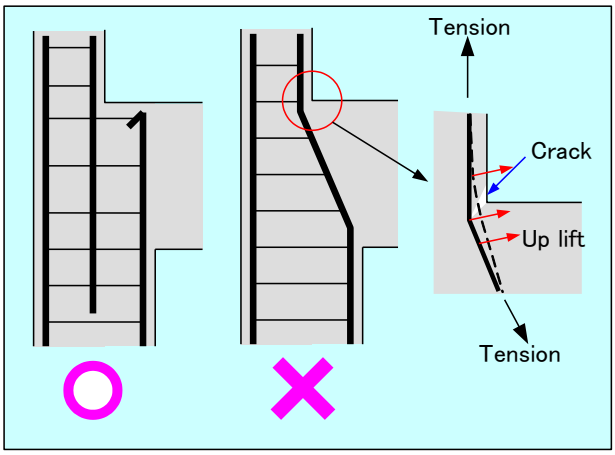


Fig-97: Large difference

2-3-6. Supporting bar

(1) In the case of cantilever beam or slab as shown Fig-98, additional supporting bars shall be installed so that to avoid settle down main bar due to the weight of fresh concrete.

(2) In the case of the double layer bar arrangement as shown Fig-99, tie bar shall be installed so that to avoid settle down main bar due to the weight of fresh concrete.

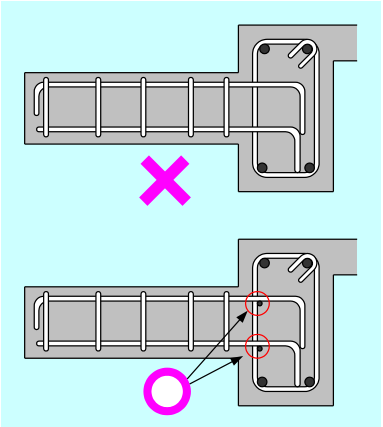


Fig-98: Cantilever beam

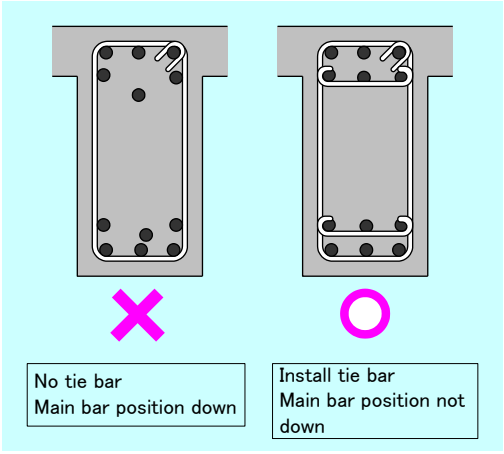


Fig-99: Double layer bar

2-3-7. Bar bending schedule

(1) Bar cutting and bending schedule drawing must be made by structural engineer.

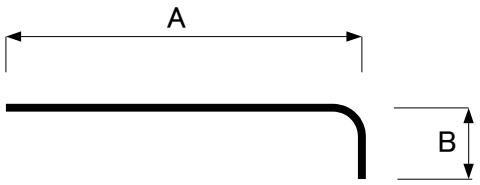
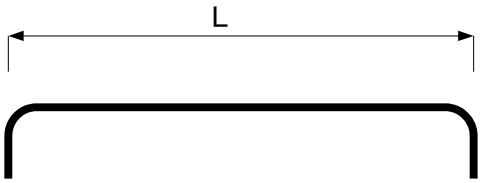
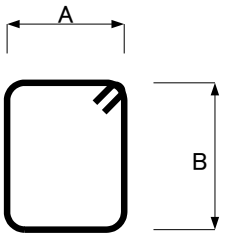
(2) On the field, bar cutting and bending work shall be done based on provided bending schedule.

(3) Don't cut and bending bar without bending schedule

(4) Tolerance of the bar bending shall conform to Table-21

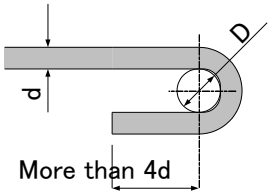
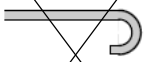
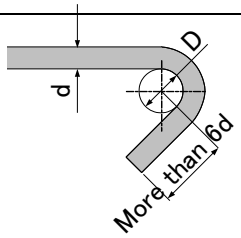
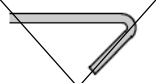
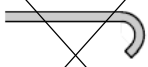
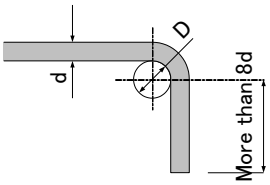
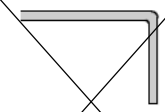
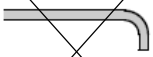
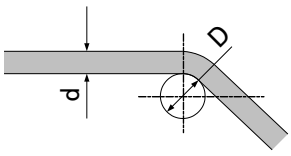
- ✧ Main bar shall ±15mm
- ✧ Overall length after cut and bending ±20mm
- ✧ Hoop and Stirrup ±5mm

Table-21 Tolerance of bar bending work

Items	Method of measuring	Tolerance
Main bar		**A, B** **±15mm** (in case less than D25)
Overall length after the cut and bending		**L** **±20mm**
Hoop and Stirrup		**A, B** **± 5mm**

(5) Type and standard dimension of end of steel bars

Table-22 Detail of standard hook and bending schedule

Bending Shape		D		Previous location	✕	✕
		Under 16mm Dia	19 to 38mm Dia			
180°		More than 3d	More than 4d	Main bars for Column and beam etc		
135°		More than 3d	More than 4d	Stirrup, Hoop, Spiral bar		
90°		More than 3d	More than 4d	Stirrup, Hoop, Spiral bar		
Less than 90°		More than 4d	More than 6d			

- ✧ Deleteriously bent or defective bars shall not be used.
- ✧ Once steel bars are bended, don't re-bend to use

(6) Bend direction

Deformed bar shall be bend laterally to the rib as shown Fig-100, don't bend right angle to the rib as shown Fig-101.

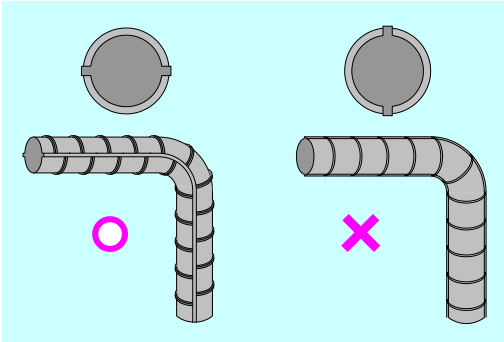


Fig-100: Correct bend	Fig-101: Incorrect bend

2-3-8. Bar assembling

(1) To secure the enough concrete cover is very important factor for quality of concrete.

(2) Unless otherwise noted, the minimum concrete cover shall conform to Fig-23.

Table-23: Standard of concrete cover thickness for Steel Bars

Type of structural elements			Minimum of Protective Concrete Cover thickness
Elements not in contact with soil	Slabs and Walls	With finishing	20mm
		No finishing	30mm
	Columns and Beams	With finishing	40mm
		No finishing	40mm
Elements contact with soil	Columns, Beams, Floors, Slabs and Walls		50mm
	Foundation and Retaining Wall		70mm

(3) Concrete cover shall be thickness between concrete outside surface and outside surface of the hoop or stirrup as shown Fig-102.

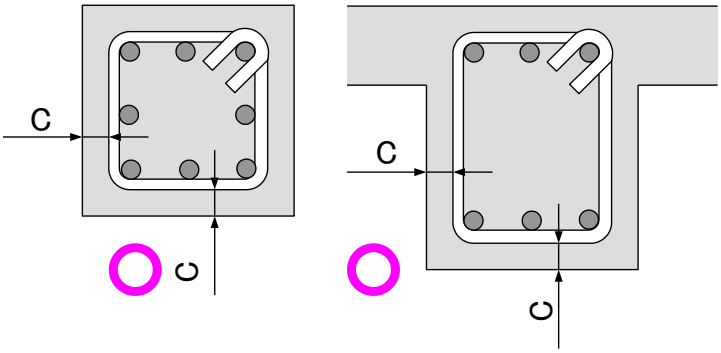


Fig-102: Correct concrete cover

(4) Concrete cover shall not be thickness between concrete outside surface and outside surface of the main bars as shown Fig-103.

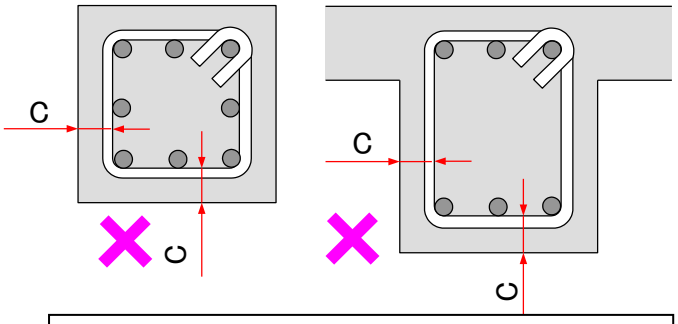


Fig-103: Incorrect concrete cover

(5) Spacer

1) In order to secure adequate concrete cover, the spacer shall be instaled as shown following Fig-105 and Fig-106.

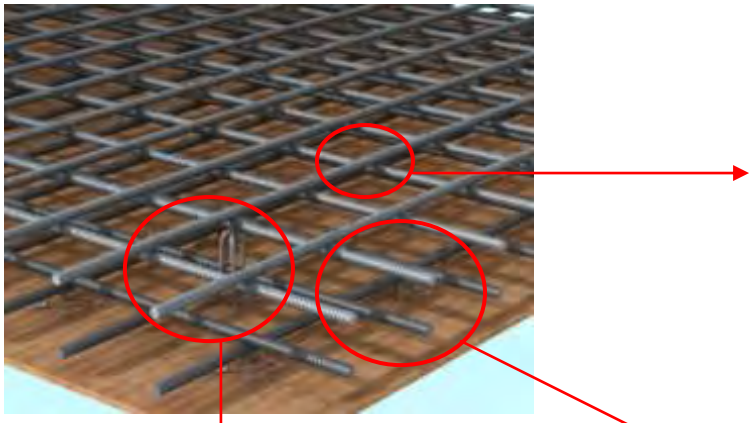
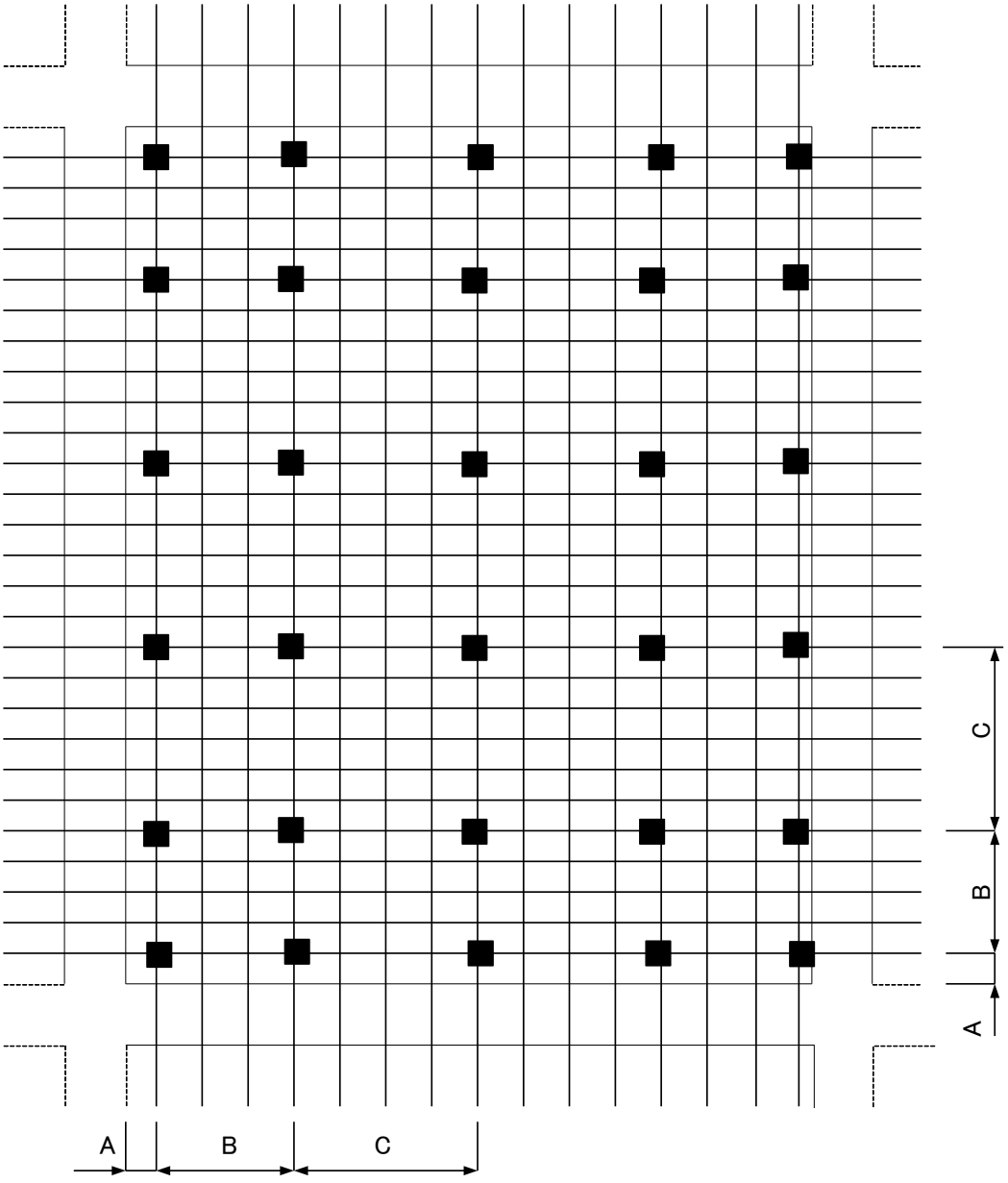


Fig-104 Bar binding

Fig-105 Spacer for upper bar

Fig-106 Spacer for lower bar

2) Standard spacing of the spacer for slab shall conform to Fig-107



■ Spacer position (Upper bar and Bottom bar)
A: Less than 10cm
B: Less than 90cm
C: Around 90cm

Fig-107 Spacer for slab

3) Girder

Spacer shall be provided both side and bottom side as shown Fig-108 and spacing shall conform to Fig-110.

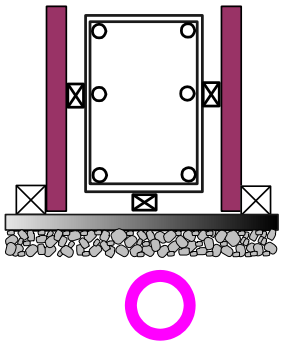


Fig-108: correct installation

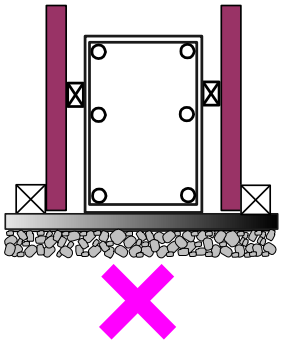


Fig-109: No spacer

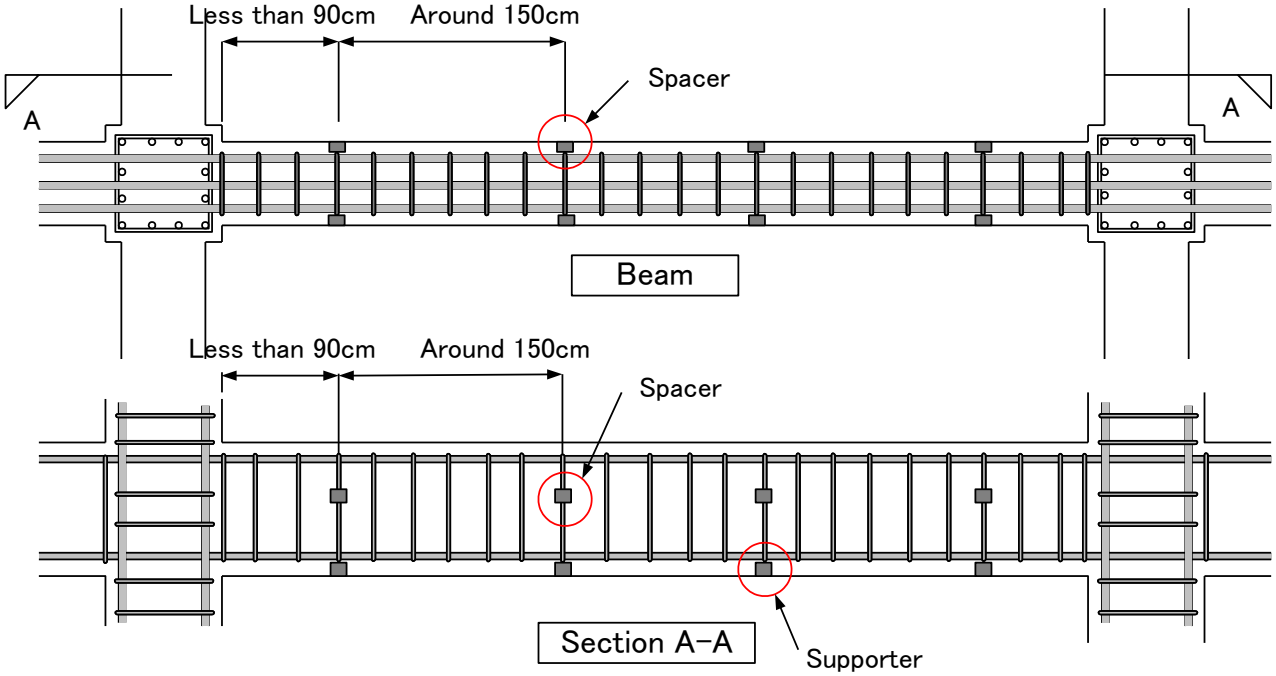


Fig-110 Standard spacing of the Beam

4) In the case of column, the spacer shall be provided to four (4) sides as shown Fig-113, and spacing shall conform to Fig-114.

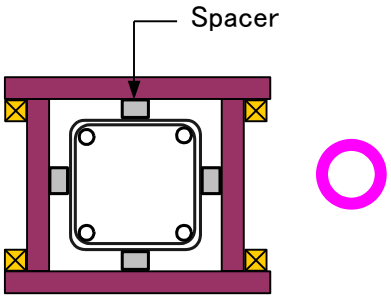


Fig-111: Correct installation

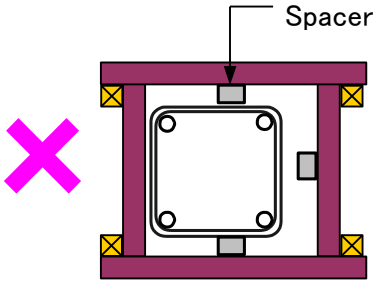


Fig-112: No spacer

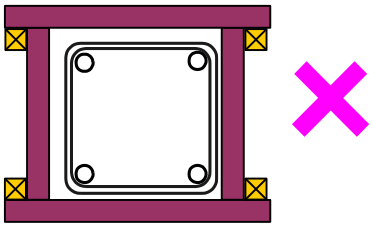


Fig-113: No spacer

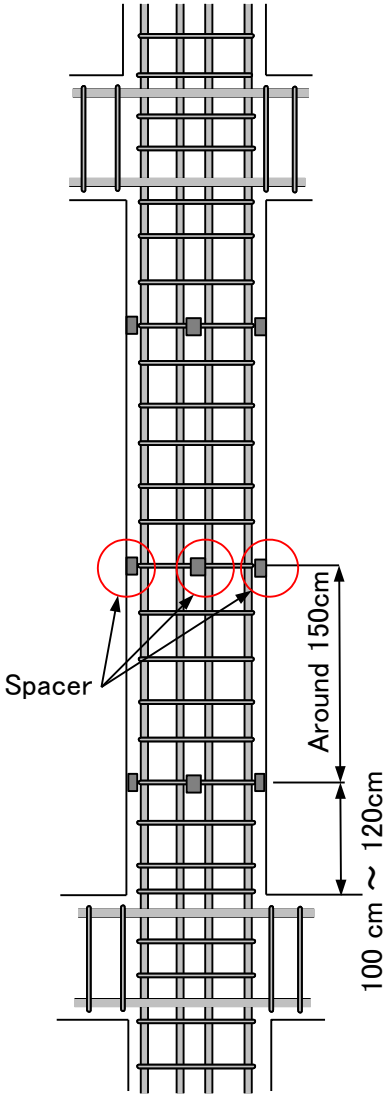
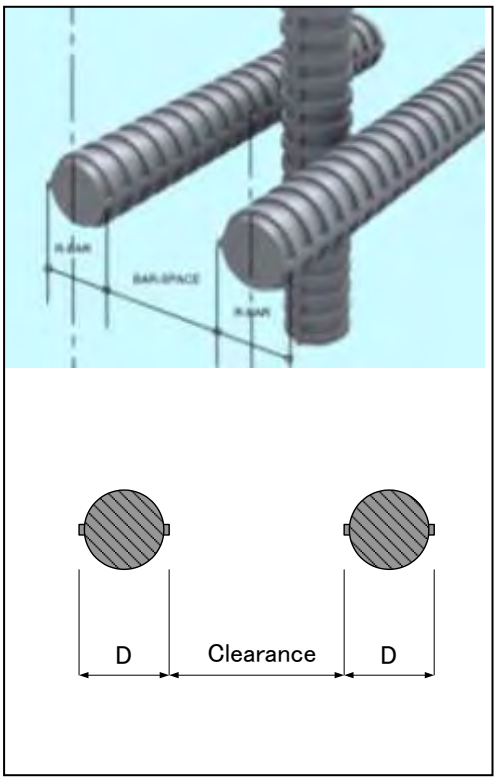


Fig-114: Standard allocation

2-3-9. Clearance of the bar

(1) The clearance between reinforcing bars shall be bigger than following manners.

1) Bigger than 1.25 times the maximum size of coarse aggregate
2) Bigger than 25 mm
3) Bigger than 1.5 times of steel bar diameter (1.5 x D)



(2) In the case of lapping bars, clearance shown in Fig-115 shall be conform to 1) 2) 3) prescribed above clause.

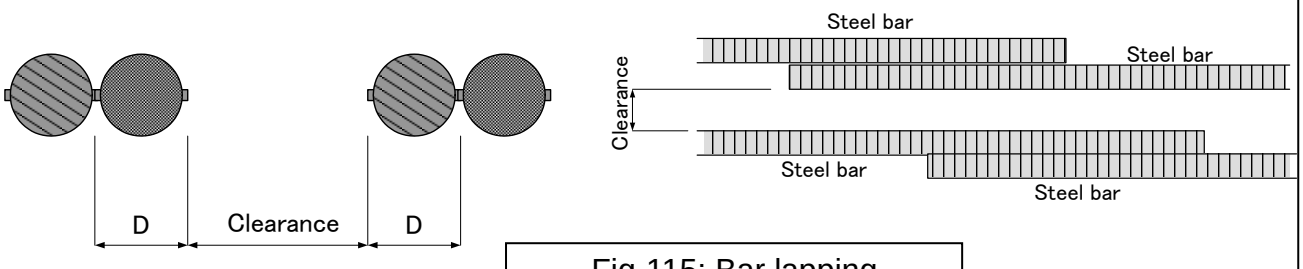


Fig-115: Bar lapping

(3) Especially, special attention shall be given to the column located to corner of the building because of the crowd bar arrangement as shown Fig-116

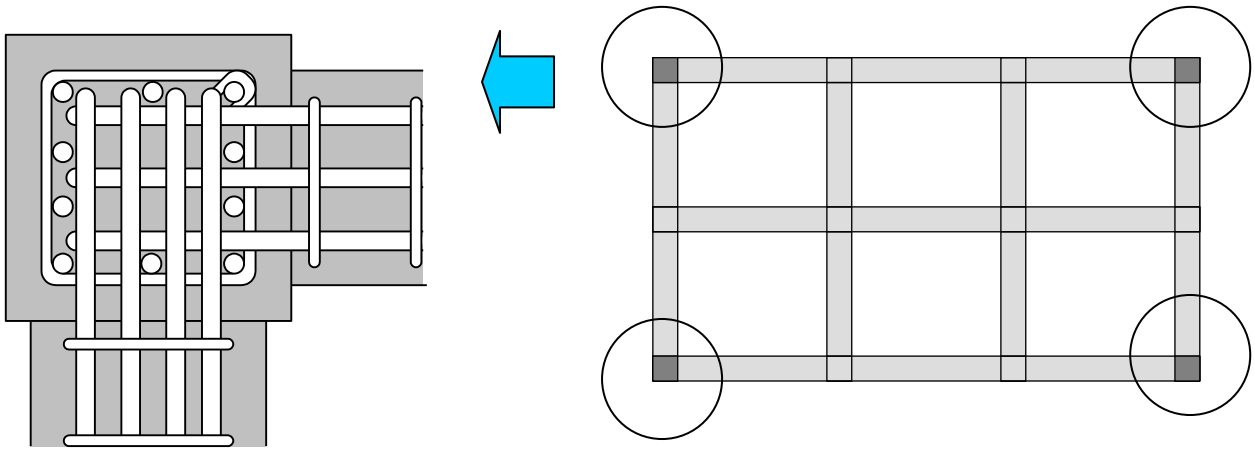


Fig-116

(4) Fig-117 and Fig 118 are example of the bad bar arrangement of the column, in these case, the steel bar shall dismantle and re-assembling again so that to secure clearance between neighboring bars.

Fig-117

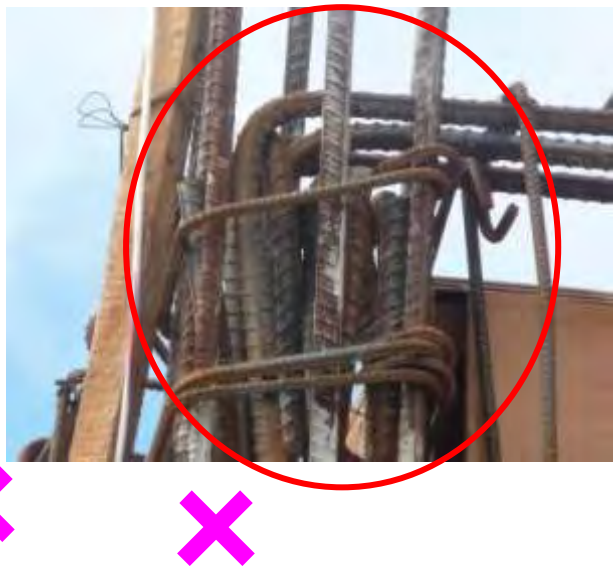


Fig-118

(5) In the case of the bar arrangement secured enough clearance as shown Fig-119, the fresh concrete must be poured closely, however, in the case of not enough clearance as shown Fig-120, cavity (air hole) must be outbreak in the concrete.

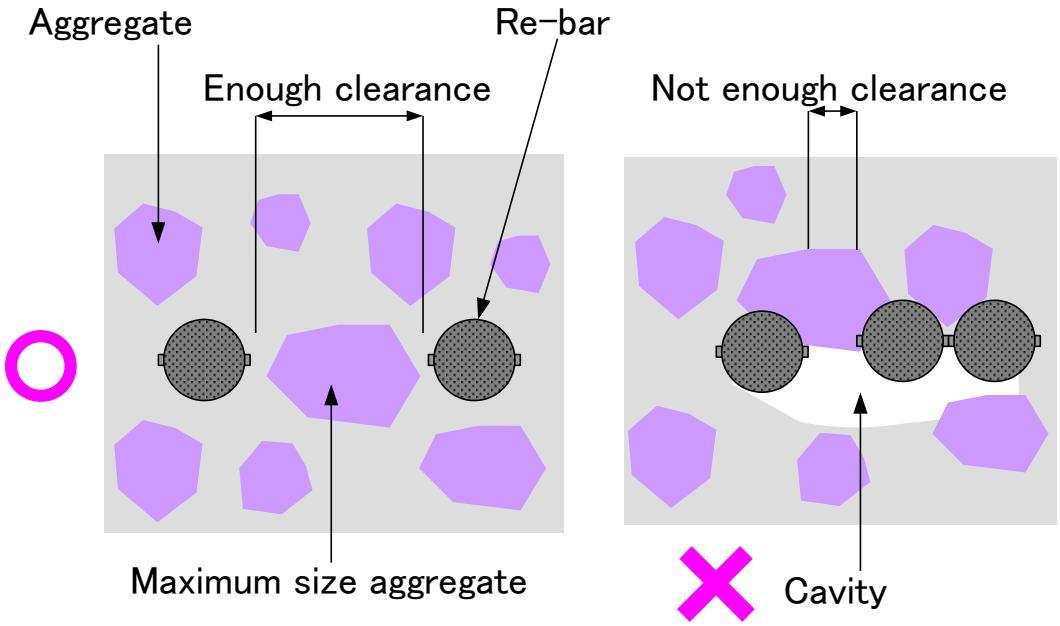


Fig-119

Fig-120

2-4 Material Stock

2-4-1 Cement

(1) Material

1) Portland cement shall conform to the requirement of SNI-15-2049-2004
2) Each consignment of the cement shall be sampled at the mill and check the mill certificate issued by the manufacture
3) Storage of cement shall nevertheless not exceed 90 days for bagged cement and 180 days for bulk cement

(2) Stock

Cement shall stock in the house protected from rain or other humidity condition
Cement shall not be stocked on the ground directly.
Cement shall stock on the pallet or equivalent more than 30cm height from the ground
Cement shall stack less than 10 bags

Fig-121

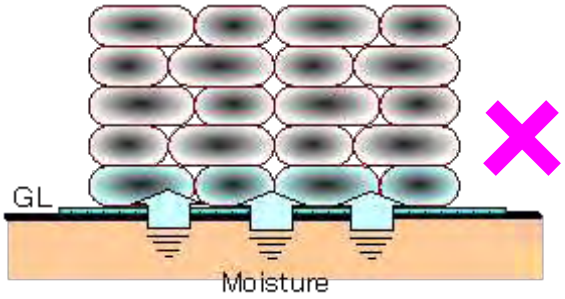


Fig-122

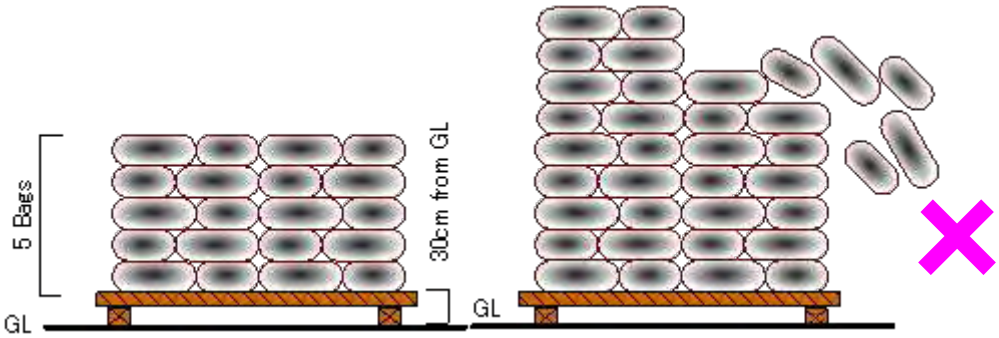


Fig-122 Fig-123

2-4-2 Steel bar

(1) Steel bar shall not be stocked on the ground directory as shown Fig-125

(2) Steel bar shall stock on the timber more than 10cm height from the ground as shown Fig-124

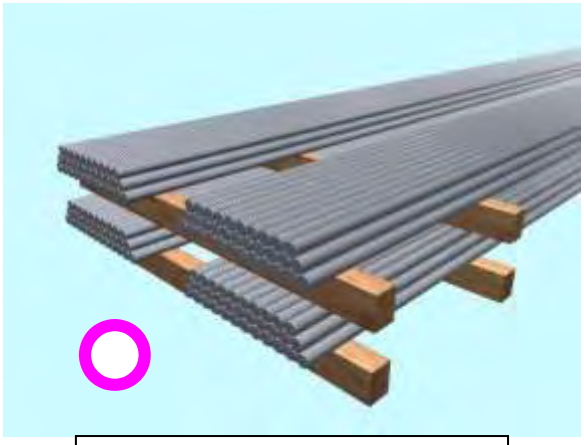


Fig-124 Correct stock

Fig-125 Incorrect stock

2-4-3 Aggregate

(1) Sand and Aggregate shall be stocked separately as shown Fig-***

(2) Sand and Aggregate shall not be stocked on the ground directory

(3) Sand and cement shall be protected from rain as shown Fig-***

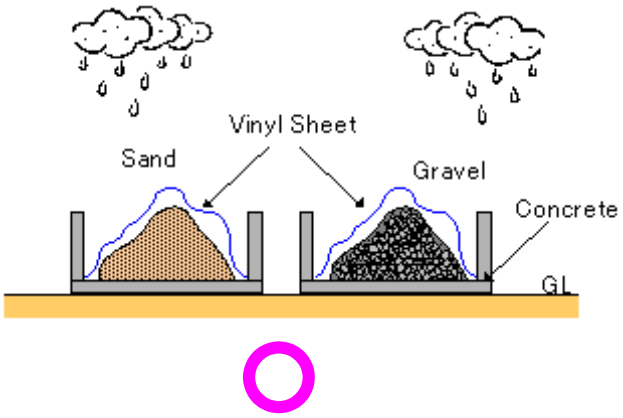


Fig-126 Correct stock

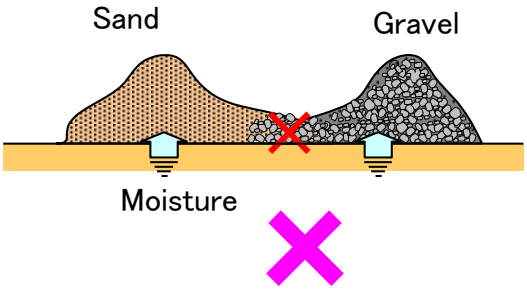


Fig-127 Incorrect stock