Appendix 7. Outline of the Trial Construction Survey

The trial construction performed as part of this survey is outlined below.

1. Outline of the survey

1.1 Outline of the survey

To compare the execution skill of local contractors with that of Japanese contractor, the following specifications were used and the contractors selected.

- Specifications: Two specifications, relatively difficult specification 1 and relatively easy specification 2, were prepared.
- Contractors: One Japanese contractor and two local contractors were selected. The local contractors were grouped into two groups, A and B, by the scale of the company, the number of engineers and other factors.
- Combination of specifications and contractors: The execution skill was compared between Japanese and local contractors based on specification 1, and the difference in workmanship between local contractors A and B was examined. The combination of specifications and contractors is shown in the table below.

	Specification 1 (difficult)	Specification 2 (easy)
Japanese contractor	○	
Local contractor A (large scale)	○	
Local contractor B (small scale)		○

1.2 Outline of the work

(1) Outline of the buildings

The specifications of the buildings for the trial construction are listed below. To compare the execution skill of the local contractors with that of Japanese contractor, the buildings were of the same scale.

		Specification 1	Specification 2
Classroom type		3-classroom block (single-storied)	
Main structure		Concrete block masonry construction	
Total floor area*		206.56 m^2	206.10 m^2
Eaves height		FL + 2.800 m	
Exterior finish	Roof	Asbestos cement sheet	
	Wall	Mortar finish (Paint finish on mortar on the gable sides)	
Interior finish	Wall	Paint finish on concrete block face masonry	
	Floor	Concrete finished with a steel trowel	Mortar finished with a steel trowel
	Ceiling	None	

* The difference in the total floor area is due to the difference in the thickness of concrete blocks and there is no difference in basic dimensions between the two.

(2) Contracted construction period

The following construction period of five months was contracted with the three contractors.

July 1 to November 30, 2002 (153 days)

(3) Contractors and construction sites

Contractors, construction sites and contract prices are listed below.

	Specification 1 (Japanese contractor)	Specification 1 (Local contractor A)	Specification 2 (Local contractor B)
Contractor	Shimizu Corporation	Sinetech Construction Ltd.	Met-weld Fabrication Ltd.
Construction site	Chunga Middle Basic School	Justine Kabwe Middle Basic School	Kalingalinga Middle Basic School
Contract price*	US$126,000	US$30,550	US$28,124

* The contract prices include the costs of desks and chairs for teachers and pupils.

1.3 Term of the survey

The originally scheduled term of the survey from the preparation for bidding to the contracted completion date was from May 27 to November 30, 2002. Due to the delay in the execution by the local contractors, the term of the survey was extended to February 13, 2003. The Ministry of Education official was commissioned to supervise the trial construction during the absence of the survey team, and the final inspection for acceptance was performed by the survey team during the stay in Zambia between February 4 and 14, 2003.

- Period between the selection of contractors to bidding: May 27 to June 30, 2002
- Construction period: July 1, 2002 to February 13, 2003

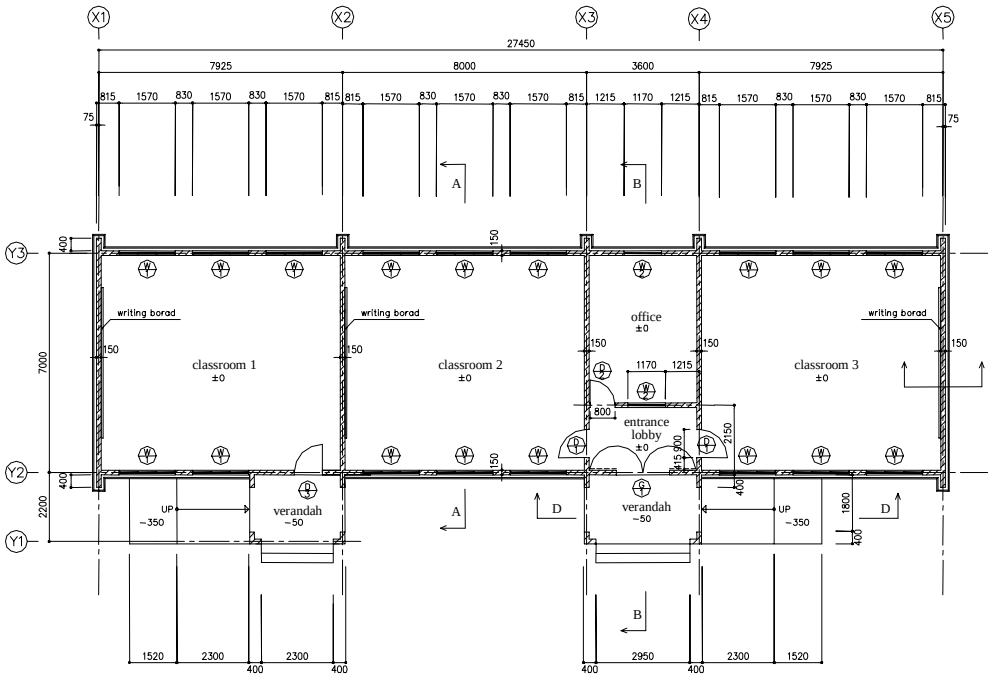
1.4 Method and details of the survey

The execution conditions of the work by Japanese and local contractors based on two types of specifications were surveyed, and comparison and evaluation were made on the following items.

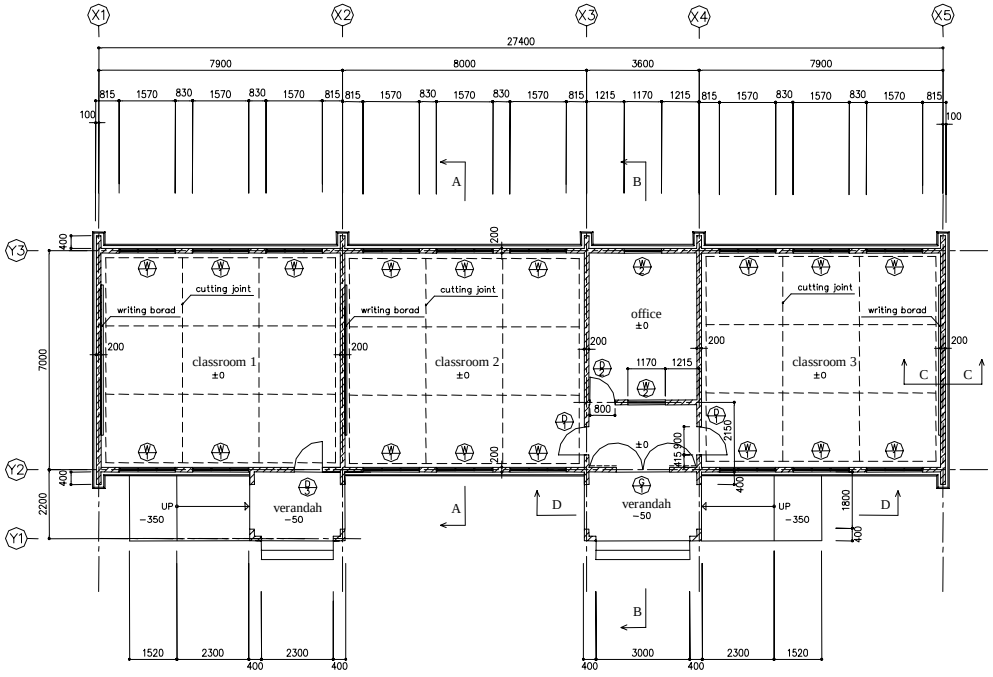
- Execution conditions, construction period, and workmanship
- Responses to the instructions given by the consultant during the implementation of the work
- Procurement conditions of materials, employment conditions of workers, construction methods, materials and others
- Execution skill of contractors
- Price and quality of construction materials, and wage and competence of workers
- Breakdown of construction costs
- Whether a Japanese engineer is needed based on the results of the above comparison and evaluation

1.5 Plans

The plans based on specifications 1 and 2 are shown below. There is no difference in the floor plan.



Specification 1



Specification 2

1.6 Photos of classroom blocks completed

Chunga Middle Basic School

Justine Kabwe Middle Basic School

Kalingalinga Middle Basic School

2. Study of the specifications of buildings for the trial construction

The specifications of buildings for the trial construction were decided based on the results of a comparison with the specifications for existing school facilities (grass-root grant aid projects, previous project, and BESSIP standards), with the local conventional construction methods taken into consideration wherever possible. To make it possible to judge whether the specifications can be adopted for the design development, the specifications were modified somewhat, such as changing the concrete block thickness from the commonly used 200 mm to 150 mm. The specifications, survey items, and viewpoints of the survey are listed in the table below.

Item		Design development	Trial construction 1		Trial construction 2	Survey item	View points of survey
			Japanese contractor	Local contractor A	Local contractor B		
Foundation		Reinforced concrete foundation, heavy block	Reinforced concrete foundation, heavy block		Reinforced concrete foundation, heavy block	Conditions of steel reinforcement placed Dimensions of foundations	Comparison of construction accuracy between two local contractors and Japanese contractor
	Subsurface treatment	Leveling concrete, t = 50	Leveling concrete, t = 50		Leveling concrete, t = 50	Thickness of leveling concrete	
		Compaction of backfilled soil, t = 150	Compaction of backfilled soil, t = 150		Compaction of crushed laterite stone, t = 150	Thickness of compacted soil Conditions of compacted soil	
Treatment under slab		Polyethylene sheet	Polyethylene sheet		Polyethylene sheet	Conditions of execution	Comparison of construction accuracy between two local contractors and Japanese contractor
		Spreading sand, t = 50	Spreading sand, t = 50		Spreading sand, t = 50	Thickness of sand spread	
		Compaction of crushed laterite stone, t = 100	Compaction of crushed laterite stone, t = 100		Compaction of crushed laterite stone, t = 100	Conditions of compacted crushed stone	
Slab		Reinforced concrete slab	Reinforced concrete slab, steel trowel finish		Reinforced concrete slab	Conditions of steel reinforcement placed Level of floor Cracking in floor	Feasibility of finishing concrete in one step Comparison of construction accuracy between two local contractors and Japanese contractor
	Arrangement of steel reinforcement	Wire mesh (ø4@150)	Wire mesh (ø4@150)		Wire mesh (ø6@150)		
	Thickness	t = 100 (same as the previous project)	t = 100		t = 100		
Wall		Concrete block 200 x 200 x 400	Concrete block 150 x 200 x 400		Concrete block 200 x 200 x 400	Width of joint, dimensions, perpendicularity, etc.	Comparison of limits of concrete block thickness Comparison of construction accuracy between local and Japanese contractors Comparison of construction accuracy between two local contractors due to the difference in concrete block thickness
Column and beam		None (circumferential girders)	None (circumferential girders)		None	Dimensions of circumferential girders, conditions of steel reinforcement placed	Survey of feasibility of laying 150 mm thick concrete blocks with circumferential girders
Roof truss		Reinforcing bar truss (spider truss) @1,750-1,810	Reinforcing bar truss (spider truss) @1,750-1,810		Reinforcing bar truss (spider truss) @1,750-1,810	Dimensions of structural members, deflection	Comparison of construction accuracy between local and Japanese contractors
Roof		Non-asbestos cement sheet	Asbestos cement sheet		Asbestos cement sheet	Pitch of roof	Comparison of construction accuracy between two local contractors and Japanese contractor
Ceiling		None	None		None		

Item		Design development	Trial construction 1		Trial construction 2	Survey item	View points of survey
			Japanese contractor	Local contractor A	Local contractor B		
Wall finish	Interior wall	Mortar finish, t = 15 With paint finish	Without mortar With paint finish		Without mortar With paint finish	Shape of concrete block, roughness of paint	Survey of feasibility of fair-faced concrete block masonry construction
	Exterior wall	Mortar finish, t = 15 With paint finish	Without mortar Without paint finish (with mortar and painting on the gable sides)		Without mortar Without paint finish (with mortar and painting on the gable sides)	Level of finished mortar, roughness of paint	Comparison of mortar finishing accuracy between local and Japanese contractors
Floor finish		Without mortar Without paint finish	Without mortar Without paint finish		Mortar finish (t = 40) Without paint finish	Level of structure	Feasibility of finishing concrete in one step Mortar finishing accuracy of local contractors
Door		Wooden	Wooden and steel		Wooden and steel	Accuracy of finishing	Comparison of construction accuracy between two local contractors and Japanese contractor
Door frame		Steel, 2,000 x 900	Steel, 2,000 x 900		Steel, 2,000 x 900	Accuracy of finishing	
Classroom window frame		Steel, 1,100 x 1,800	Steel, 1,100 x 1,600		Steel, 1,100 x 1,600	Accuracy of finishing	
Burglar-proof grating		Provided	Provided		Provided	Accuracy of finishing	
Writing board		Mortar finish 4,800 x 1,200 x 1 set	Mortar finish 4,800 x 1,200 x 1 set		Mortar finish 4,800 x 1,200 x 1 set	Thickness of mortar, level of surface	Comparison of mortar finishing accuracy between local and Japanese contractors
Chalk tray and frame		Wooden	Wooden		Wooden	Shape, conditions of installation	Comparison of construction accuracy between two local contractors and Japanese contractor
Electrical system		Provided	Not provided		Not provided		
External work		Drain gutter provided	Not provided		Not provided		
Desk and chair		Based on the Ministry of Education specifications	Based on the Ministry of Education specifications		Based on the Ministry of Education specifications	Shape, accuracy of finishing	Comparison of finishing accuracy between two local contractors and Japanese contractor
Quality testing		Provided	Provided		Provided	Results of testing	Comparison of test results between two local contractors and Japanese contractor
Defect inspection		Provided	Provided		Provided		

3. Phases of the trial construction

After receiving approval from the Ministry of Education, the trial construction was carried out through the steps of selection of contractors, bidding, and commencement of the work.

3.1 Selection of bidders

(1) Japanese contractor

Five contractors with experience in school building construction under grant aid in Atrica over the past five years were selected, and approval, including the selection method, was obtained from the Ministry of Education. After confirming their interests in this trial construction, only Shimizu Corporation showed an interest. The following procedures were done for the company.

(2) Local contractors

The long list of ten local contractors competent for the trial construction was obtained from the Ministry of Education. The company scale, construction revenues and others were obtained and their interest in the trial construction confirmed. One of the ten contractors was removed from the list of bidders because it is located in Copperbelt Province. The remaining nine contractors were interviewed, and they all showed interest in the trial construction; but one contractor, because its capital stock was far below the budget price, was removed from the list of bidders. Judging from the construction revenues and the number of engineers of the remaining eight contractors, the top and the bottom four contractors were grouped into groups A and B, respectively.

Comparison of local contractors

	Contractor	Capital (US$)	Number of engineers	Annual construction revenue (x US$1,000)						Group
				1997	1998	1999	2000	2001	Average	
1	Wah Kong Enterprises	500,000	5	650	2,189	1,850	1,100	1,600	1,478	B
2	Prince Construction	500	2	1,100	1,120	1,280	572	510	916	×
3	Dockland Construction	70,000	8	1,893	1,924	1,919	2,135	2,049	1,984	B
4	Sinetech Construction	450,000	10	800	1,200	1,800	3,500	2,500	1,960	A
5	Huang Jiangxi International	1,800,000	12	750	1,250	1,850	2,200	1,750	1,560	A
6	China Jiangxi International	200,000,000	5	38,369	48,171	65,271	59,472	56,470	53,551	A
7	Millers Construction Ltd.	168,500	15	1,448	3,403	2,539	3,754	1,841	2,597	A
8	Met-Weld Fabrication Ltd.	1,600,000	4	2,920	3,080	3,961	4,381	7,177	4,304	B
9	Astro Works	250,000	6		260	1,065	1,090	670	771	B

3.2 From site orientation to contract award

(1) Site orientation

The site orientation was held in the order of local contractors A and B and the Japanese contractor in the presence of the staff of the JICA Zambia Office and the officials of Construction Bureau, Ministry of Education, from 10 a.m. on June 7, 2002.

(2) Bidding, opening of bids and contract negotiation

Bids were received and opened in the order of local contractors A and B and Japanese contractor in the presence of the staff of the JICA Zambia Office and the officials of Construction Bureau, Ministry of Education, from 10 a.m. on June 19, 2002. All bids on the first bidding were below the budget price, and contract negotiations were conducted in the afternoon.

(3) Contract award

The results of the bidding were reported to the headquarters and Zambian office of JICA for approval. The contract with each contractor was concluded on June 24, 2002. The date of the commencement of the work was set to be July 1, 2002.

4. Results and evaluation of the bidding

The results of the bidding are shown in the table below. Each bidder submitted a bid below the budget price in the first bidding. The reason that the bid price offered by Japanese contractor was approximately four times more than those by local contractors is that the scale of the trial construction was small and therefore the overhead of the Japanese contractor was much higher than that in actual construction projects. This was not typical of construction projects executed by the contractor.

The contract prices of local contractors were less than one-half the budget price. Upon close inspection of bid prices, one contractor submitted a bid price that was 89% of the budget price. There is a difference of approximately two times in bid prices depending on the scale of contractors. The cause of this seems to be the difference in overhead ratio. Particularly, because the scale of the trial construction was small, small- and medium-sized contractors were more advantageous than others. The results of a study on the breakdown of the bid prices offered by the successful bidders show that some unit prices were less than the minimum wages in Zambia. Because the bidding took place in the county where volume of construction is extremely low, it cannot be denied that a deep discount was given.

Unit: US$

	Contractor	Specification type	Bid price	Budget price	Ratio of bid price to budget price
Japanese contractor	Shimizu Corp.	1	127,400	128,049	0.99
Local contractor A	China Jiangxi Intrnational	1	59,761	67,287 (0.94)	0.89
	Huang Jiang Investements Ltd.		47,536		0.71
	Millers Construction Ltd.		35,091		0.52
	Sinetech Construction		32,056		0.48
Local contractor B	Astro Works	2	38,069	71,328	0.53
	Wah Kong Enterprises Ltd.		31,858		0.45
	Dockland Construction		30,776		0.43
	Met-Weld Fabrication Ltd.		28,264		0.40

Notes: The contractors in the colored cell are successful bidders.
The figure in parentheses indicates the ratio of the budget price based on specification 1 to that on specification 2.

The results of an evaluation of the bid prices are described below.

As a result of a comparison of the breakdown of the bid price submitted by Japanese contractor by work type, the difference between the bid and budget prices was less than 20%, except for the earthwork, and there was no overestimation or underestimation. The cost of the earthwork was judged to be reasonable because the cost of excavation in the rocky ground at the project site in Chunga, which was inconceivable when design budgets were made, was added. (Actually rocks were excavated during the trial construction.)

In the breakdown of the bid prices offered by local contractors, the cost items did not include direct temporary work, field expense, or overhead. Because there was no need to station a full-time field

construction manager, as was the case with Japanese contractor, the maintenance costs of field office and others were shared with other cost items, allocated to each cost item, and not described in the breakdown. In addition, the bid prices were far below the budget prices for the type of work where labor cost is proportionately higher than the material cost, such as earthwork, structural work, interior and exterior finish works. On the other hand, the bid prices were within 20% of the budget prices for the type of work where the material cost is proportionately higher than the labor cost and where the work has high ratio of dependence on subcontractors, such as roof work, doors and windows and furniture works. It is open to question how the local contractors coped with legal minimum wages. It was confirmed during interviews with the local contractors that they strictly observed the legal minimum wages. In addition, the bill of quantity was almost equal to that estimated for the design budget and there was no error by oversight in the bill of quantity.

5. Comparison and evaluation of execution conditions

5.1 Execution conditions and methods

The specifications adopted for the trial construction were those generally used in Zambia, and there were no major differences in the basic execution methods or main construction equipment between Japanese and local contractors. The Japanese contractor drew up a comprehensive scheme of execution, construction and quality management plans and shop drawings and carried out the work efficiently. However, the scheme of execution or shop drawings prepared by the local contractors were either insufficient or were not comprehensive. Their inefficient execution conditions were frequently observed.

5.2 Construction period

Concerning the contracted completion date (November 30, 2002 (153 days)), the actual completion date of the trial construction by each contractor was as follows.

- Japanese contractor (Shimizu Corporation): November 26, 2002 (149 days)
- Local contractor A (Sinetech Construction): February 10, 2003 (225 days)
- Local contractor B (Met-Weld Fabrication Ltd.): December 26 (179 days)

Japanese contractor procured materials, assigned staff and prepared work procedures according to the plan, whereas the arrangements made by local contractors were insufficient in every way. Further, their inadequate quality control led to re-fabrication and re-execution, having adverse effect on the construction period.

5.3 Workmanship

Taking a broad view of the finish work, there was no great difference in the workmanship between Japanese and local contractors. In terms of the workmanship of details, the accuracy of dimensions, perpendicularity and others, local contractors are quite inferior to Japanese contractor. However, the degree of the deficiency was not so large as to impair the functionality of the buildings.

5.4 Procurement conditions and quality of materials

Concerning the procurement of materials, local contractors were incapable of procuring materials according to the plan with the construction schedule in view. For example, Japanese contractor procured materials and started fabrication at the end of July in preparation of erecting trusses at the end of September, whereas local contractors waited until early September to procure materials, which greatly affected the progress schedule. In addition, the contractors failed to bring in concrete according to the schedule of casting concrete and plaster work. Workers were often observed standing idle at the field. There was a case where the procurement of materials was delayed due to lack of funds.

As regards the quality of materials, the materials manufactured generally to the specifications and performances in the contract drawings were used. Materials of low quality that affect the quality of the buildings were not used.

5.5 Instructions and responses to the instructions

Instructions given during the execution of the work were mainly regaring the following items:

(1) Safety control

(2) Scheme of execution before commencement of work

(3) Work procedures of each work and process, and quality

Concerning items (1) and (2), there was no need to give instructions to Japanese contractors. The instructions were given to local contractors, and their responses to the instructions were very slow. No actions were taken to the instructions to wear hard hat, improve the structure of scaffolding, or prepare shop drawings. This is due to the fact that legal provisions for safety control are not strict and supervisors and workers have no awareness regarding safety control. As regard the scheme of execution, the work was rarely carried out according to the plan even if the scheme of execution was drawn up because the contractors had problems with the procurement of materials and securing of workers and did not have a habit of preparing schemes of execution and shop drawings.

Concerning item (3), by the time of the next construction step, remedial actions were taken in response to the instructions. As compared with Japanese contractor, instructions had to be given more frequently to local contractors. This is due to local contractors' lack of awareness regarding quality control and their insufficient quality control systems.

6. Conditions of workers

6.1 Employment conditions of workers

The differences in the employment conditions of workers between Japanese and local contractors are as follows.

(1) Skill in mobilizing workers

Japanese contractor unfailingly secured workers through subcontractors, and was capable of mobilizing workers for the type of work that requires a large work force, such as casting concrete, to proceed with the work with efficiency over a short term. On the contrary, local contractors were incapable of securing the required number of workers even for the work requiring a large work force, such as casting concrete and taking the final step for finish work.

(2) Operating efficiency of workers

There was much difference in the work progress even at the time when the number of workers employed by Japanese contractor was comparable to that by local contractors. Primary causes of this are the low operating efficiency due to insufficient instructions given by the supervisors to workers and the time wasted in waiting due to planless delivery of construction materials.

(3) Payment conditions of wages

Workers employed by local contractor frequently expressed dissatisfaction regarding the payment of wages and have refused to work a few times because of nonpayment of wages.

6.2 Workers' skills

There was little difference between the skills of workers employed by Japanese and local contractors. However, the difference in the finishes of concrete block masonry and plaster work was evident. This is due to the fact that workers were not supplied with equipment for improvement of precision of work. In addition, supervisors employed by local contractors had low awareness regarding workmanship. The difference in the workmanship was caused by the difference in the equipment supplied by the contractors and the instructions given by the supervisors.

7. General overview of the trial construction

7.1 Local contractors' execution skill

(1) Execution skill by work type

1) Earthwork and foundation work

Due to the good soil conditions, there was hardly any difference in the execution skill between Japanese and local contractors. Local contractors understood the necessity and procedures for compacting backfilled soil, and used equipment comparable to that supplied by Japanese contractor. For this reason, the workmanship comparable to that of Japanese contractor may be obtained, although it depends on the presence or absence of a construction manager (supervisor.)

2) Steel reinforcement work

The skill of local contractors to arrange steel reinforcement is judged to be comparable to Japanese contractor if the shape is simple. For connections of complex shape, it is unlikely that good results can be obtained due to the lack of a skill to formulate the scheme of execution.

3) Concrete work

Problems associated with the scheme of execution, such as the malfunction of concrete mixers, mistakenly arranged construction materials including concrete, were exposed. The mixing, casting and curing of concrete were done without any particular problems under the direction of Japanese supervisor and locally employed supervisors. It can be judged that there will be no problem with the execution skill if the management system for the procurement of materials and the maintenance of equipment functions properly.

4) Formwork

The workmanship of concrete was poor due to the faulty levelness of sheathing boards. It cannot be denied that local contractors had low awareness regarding construction materials with workmanship in view. However, forms were constructed properly without any particular problems.

5) Concrete block work

Local contractors started the work without advance study of the arrangement of concrete blocks, and improperly adjusted the dimensions of joints. As a result, it took a long time to carry out the work around doors and windows, at the corners of walls, and at the sections where walls crossed, which reduced working efficiency.

To check the possibility of reducing costs, the specifications required the concrete block face masonry to be laid without mortar finish. However, because the locally produced concrete blocks

were irregular in shape and judged unsuitable for the work, the concrete blocks were mortar finished in the actual construction work.

6) Reinforcing bar truss work

Local contractors had little understanding of basics of theory of structures: for instance, they tried to use reinforcing bar trusses joined upper and lower chords. In addition, lack of a product inspection (acceptance inspection) system was observed; for example, unsized trusses were carried into the site.

7) Painting work

Local contractors had a certain level of technical know-how regarding painting and were judged to be comparable to Japanese contractor. However, their preparatory plan before starting painting was insufficient, and the checking after completion of each painting sequence was improper. Depending on the situation, this will affect the quality of the work.

8) Door and window work

No major problem was observed in particular with the workmanship of products. Because local manufactures had low awareness regarding the dimensional accuracy of products, local contractors accepted and installed, in some cases, products with low dimensional accuracy as they were. When installing door and window frames, Japanese contractor checked the position and perpendicularity with accuracy, whereas local contractors were far beneath Japanese contractor in installation accuracy.

9) Roofing work

There was no problem with products because the roofing materials manufactured to the specifications were used. However, local contractors had many problems with construction methods: for example, they adopted construction sequences that did not consider the direction of the wind, improperly secured hook bolts due to low awareness regarding measures against water leaks.

10) Plaster work

Local contractors gave adequate consideration to cracking and carried out the work while checking the mix proportions of cement and sand. Consequently, no major cracks were observed. However, local contractors had low awareness regarding the finishing of the work with accuracy. For this reason, perpendicularity and plumbness were unsatisfactory.

11) Furniture work

Local contractors used ready-made furniture without giving due consideration and in some cases the dimensions were insufficiently checked. Accordingly, there is a risk that furniture with dimensions different from contract drawings will be delivered to the site.

(2) Construction management skill

Because the work was not carried out according to a plan, corrections had to be made frequently at field. Particularly for connections of reinforcing bars of complex shape, because advance study was not made, much time was taken to make adjustments on site. One local contractor prepared the shop drawings of concrete blocks but did not use the drawings at the field. The local contractor had little understanding of the importance of preparing the shop drawings.

In addition, the work progress was badly affected by planless procurement of materials, delivery of the materials without acceptance inspection and inadequate maintenance of equipment.

(3) Safety control skill

Local contractors lack consciousness regarding safety control. Specifically, even field engineers were not wearing hard hats and some workers were barefoot at the field. Concerning the scaffolding for work at elevated positions, bracing was insufficient and toe boards were tied improperly. A safety control system was almost nonexistent.

(4) Quality control

In Zambia, material suppliers, users and control institutions lack awareness regarding quality control of materials. The reason for this may be due to the fact that requirements for building quality are limited based on good soil conditions under favorable natural conditions without earthquakes or strong winds.

1) Steel reinforcement

Most of the steel reinforcement is imported from South Africa, and there is no problem with the material of the steel reinforcement. Considering the condition of the material in Zambia that it is impossible to check the material against the mill sheet at wholesale dealers, there is a risk that defective products will be mixed. In addition, local contractors have no awareness regarding the responsibility as a contractor for the physical properties of the material, such as the strength of steel reinforcement.

2) Concrete

Local contractors lack a sense of responsibility as a contractor for concrete strength and consider observing the specifications of mix proportions to be sufficent. They rarely conduct compression

testing and do not care to make corrections even when test specimens are of bad shape and the strength of concrete is insufficient.

3) Concrete block

Local contractors have little understanding of the necessity for checking the strength of concrete blocks as is the case of the strength of concrete. However, leading concrete block manufactures control the strength of their blocks.

4) Doors, windows and furniture

Manufactures and local contractors have an inadequate system of checking the workmanship, including dimensional accuracy. There is a risk that defective products will be delivered to the site.

5) Various finishing materials

There was no major problem with the quality of various finishing materials.

(5) Skill to procure materials

Local contractors lack the skill to procure materials according to the plan, with the schedule in view. This has a profound effect on the progress of the work.

It seems unlikely that materials with problematic quality will be procured if specifications and performances are specified in contract drawings. For the materials for which specifications or performances are not specified, such as forms, there is a risk from a standpoint of lack of funds that the materials conforming to the requirements on the Japanese side will not be procured.

As described above, it seems necessary to have the Japanese give local contractors guidance on the procurement of materials from not only a technical but economical aspect.

(6) Employment conditions and skills of workers

The subcontractors of Japanese contractor employed many workers at a reasonable wage, and had a system of mobilizing workers for the type of work requiring a large work force, such as casting concrete. On the other hand, local contractors had the problem of paying wages to the workers, and the lack of regular workers detrimentally affected the work progress. It was made clear that they had problems with employment conditions and systems.

Workers seem to have the skills to ensure at least satisfactory workmanship if guidance is given by the Japanese supervisors.

7.2 Degree of involvement of Japanese engineers and important control items

Based on the results of the trial construction, the execution system required for Japanese contractor to effectively use local contractors as well as reduce costs is considered as follows.

(1) Confirmation of the extent of using local contractors

1) Work items for which comparable quality and workmanship can be expected without direct instructions by Japanese engineers

(1) Earthwork and foundation work (excavation and compaction)

(2) Casting and curing concrete

(3) Placing steel reinforcement of simple shape (Training will be required for the location and length of joint and others.)

(4) Formwork (For the material of sheathing boards, training or material selection by the Japanese will be required.)

(5) Concrete block work with mortar finishing

(6) Quality control of various finishing materials and basic work schedule control by work type (For the adjustments at tie-in points between different work types and construction methods to ensure dimensional accuracy, training will be required.)

2) Work items for which instructions to be given by Japanese engineers or needed to be performed directly by Japanese contractor

(Work items for which instructions are necessary from the standpoint of technology transfer but difficult to be expected at the beginning)

(1) Execution planning (preparation of shop drawings, study of construction sections of complex shape, and others)

(2) Schedule control (training of key points in schedule control)

(3) Safety control (consciousness-raising training of safety control and technical training of structure of scaffolding and others)

(4) Quality control (consciousness-raising training of quality control and technical training of preparing test specimens and others)

(5) Procurement of materials timed to coincide with work progress and quality (procurement of materials based on schedule and quality control)

(2) Establishment of construction phases

In the previous project, eight schools (23 or 20 classrooms per school, 181 classrooms in total) were constructed in two phases, although there was a difference in the components. Judging from the fact that local contractors required a construction period 1.5 times longer than Japanese contractor for the trial construction, three phases will be necessary for local contractors to construct 12 schools (24 classrooms per school, 288 classrooms in total.) However it can be judged sufficiently possible to construct 12 schools in two phases by effectively using local contractors and appropriately stationing Japanese contractor for schedule control. However, appropriate construction management with the total construction volume and period in view will be necessary without relying too much on local contractor's skills.

(3) Establishment of required number of Japanese engineers

Based on the requirements described in (1) and (2), the primary role of Japanese architectural engineers is to perform administrative tasks that cover the scope in which local contractors are incapable (execution planning, scheduling, safety and quality control planning.) Concrete personnel organization and their roles are described below.

1) Field manager: one man-year

As an engineer responsible for supervising the field personnel organization, including Japanese engineers, the field manager should be stationed over the construction period. Main tasks are to draw up execution, safety and quality control plans as well as create an implementation system.

2) Architectural engineer: one man-year

As an engineer who gives training, implements, controls and checks the scheme of execution, safety and quality control and procurement of materials at all project sites, the architectural engineer should be stationed over the construction period. However, because it is impossible for one engineer to control the tasks at all the sites, the Japanese engineer should check approximately 40% of inspections for quality control and commission local general contractors and engineers to check the remaining 60% and report the results of the inspections to the Japanese engineer, for example. Accordingly, it is indispensable to give local contractors sufficient guidance on each control item prior to commencing the work.

Further, the architectural engineer should control the procurement of materials which are required to be procured according to the plan, with the overall schedule taken into account. Because the number of construction sites are more than that in the previous project, one assistant field manager plus one assistant architectural engineer, two persons in total, should be added, i.e. four-person organization structure including the field manager, during the period when phases 1 and 2 overlap.

3) M&E (electrical pluming and borehole) engineer and clerical worker: one man-year in total

M&E engineer and clerical worker should be dispatched to the field over a time period when their control tasks is most necessary to reduce the involvement of the Japanese. Assuming that they will work part-time, a total of one person year in each phase is considered.

Comparing the man months established above with those for the previous project, the man months per school are reduced to 44% of the actually required man months for the previous project and the manpower costs, including traveling expenses, also decreased to 49%.

7.3 Optimum design

Based on the results of the trial construction, the basic design policy to effectively use local contractors is established as follows.

(1) Cost reduction from a design standpoint

To reduce direct construction costs by making the most of the results of the trial construction, local construction methods and materials should be actively used and improved as follows.

1) Adoption of masonry construction

Concrete block masonry construction is the type of construction commonly adopted in countries not subject to earthquake and also in the BESSIP standards. The construction, free of columns and beams, can shorten the construction period. In addition, local contractors are familiar with the construction. For these reasons, the construction has the merit of reducing the involvement of Japanese engineers.

2) Use of locally produced concrete blocks

Locally produced and used concrete blocks are far lower in strength than Japanese ones. However, the blocks are structural materials supporting only vertical loads without earthquake loads. Accordingly, the locally produced concrete blocks that meet design strength requirements should be actively used. In addition, because the concrete blocks have rough surfaces and lack dimensional accuracy, the blocks are unsuitable for concrete block face masonry construction and therefore locally used mortar finish should be adopted.

3) Elimination of crushed stone bedding for foundations

The soil conditions are good at each site and in trial construction, no problems were found with buildings that did not have crushed stone bedding for foundation. For this reason, the requirement of crushed stone bedding for foundations can be eliminated.

4) Elimination of floor mortar finishing

Because no problem was found with the floors finished directly with concrete by local contractors, the floor mortar finishing can be eliminated.

(2) Cost reduction from an execution standpoint

From a design standpoint, active adoption of local construction methods and materials makes it possible to increase the volume of work entrusted to local contractors, relatively reduce the man hours of Japanese engineers as well as reduce construction costs. In practical terms, rework due to local contractors' ill-conceived scheme of execution and time wasted in waiting due to planless procurement of material were often observed during the trial construction. It is also an important factor for cost

reduction to avoid such waste of time and carry out the work efficiently by strengthening the control of local contractors by Japanese engineers. To be more precise, it is necessary to hold regular meetings to keep all project members, including local contractors, well informed, provide training and transfer technology concerning construction management, and at the same time raise consciousness regarding their participation in the project. Resultingly, this makes it possible to reduce costs as well as ensure the quality of grant aid.

8. Future prospects

In the light of the results of the trial construction, the proper course of Japanese grant aid is discussed below from the viewpoint of project cost reduction, assurance of construction quality, safety control, schedule control and technology transfer.

8.1 Necessity for Japanese engineers

Fundamentally, the objective of the construction supervision by the consultant is to confirm that contractors have construction management capability so that completed buildings satisfy the design concept and specifications. From the trial construction, it became clear that it is impossible for the consultant to guarantee and take over the responsibility of construction management for local contractors who are lacking quality, safety and schedule control capabilities. The trial construction revealed that it is possible to minimize the problem by the consultant giving instructions and guidance, but difficult to completely eliminate the problem.

For the technology transfer, although it is possible to make it a reality through on-the-job technical training by Japanese contractor, there will be cases where it is impossible to employ the technology transferred by Japanese consultant alone, depending on the level of local contractors' skill. It seems unlikely that the technology transfer will be sufficiently effective.

As stated above, construction management by Japanese contractor is essential and resultingly the objective will be almost accomplished. Further effect is promising if guidance and direction are given by Japanese consultant.

8.2 Future prospects

At the present stage, there are institutional problems, such as guidelines, contractual problems with the consultant, and problems with quality and schedule control under grant aid. Therefore the current construction management and supervision system is considered best. It can be judged effective for reducing project costs by minimizing the involvement of Japanese engineers and by adopting local specifications wherever possible after clarifying the requirements for the quality of grant aid, and making the effective use of local contractors after assessing in detail the execution skill of the local contractors.