

## III-2. Brick Facing Method for Reinforced Concrete Construction with Thin Bricks

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### ABSTRACT

*The traditional brick (or tile) facing method in Japan has been improved to new, more effective methods, together with technical improvement such as increase of bond strength of bricks, but on the other hand, as seen in accidents of tile fracture, the situation that reliance for construction is falling by bad construction or shortage of skilled layers cannot be overlooked.*

*The site-prefabricated brick (or tile) construction was developed in this situation to abbreviate construction works, or to shorten the term of construction and reduce the construction cost, after the accumulation of studies on construction techniques and improvement of quality of products aiming the safety of construction such as prevention of brick (or tile) fracture.*

*Bricks and tiles have many superior merits as outer or inner facing materials, such as familiar touch, humane warmness, simplicity and advantage of maintenance free, and the site-prefabricated construction to utilize these features has high reliance to prevent fracture, efflorescence or frost damage.*

### PREFACE

The traditional method of laying thin tiles is to place mortar onto the tile and then lay the tile against the plastered wall. Improvement in the bond strength of the tile has been achieved by either mortaring the plaster and immediately laying the tile or partly mortaring both the tile and the wall before laying. However tile failures do occur due to bad workmanship and there is also the problem of a shortage of skilled tile layers. "Site-prefabricated brick (or tile) construction" was developed in Japan to reduce both the time of construction and its cost. Studies of construction techniques and improvement in quality of products are aimed at safety of construction such as the prevention of brick (or tile) failure.

The purpose of this paper is introduction of this method of construction. Bricks and tiles have many superior merits as outer or inner facing materials, such as familiar touch, humane warmness, simplicity and advantage of being maintenance free. The "Site-prefabricated brick (or tile) construction" combines these features with high reliance to prevent fracture, efflorescence and frost damage.

### SUMMARY OF THE "SITE-PREFABRICATED BRICK (OR TILE) CONSTRUCTION"

In this method, bricks and pre-fabricated units manufactured at the factory are set in the outer frames according to the layout lines at the construction site, and after reinforcing work and building of inner frames, concrete is cast. After stiffening and curing of concrete, frames are stripped and bricks and concrete becomes one body with the brickwork of high bond strength.

The "Site-prefabricated brick (or tile) construction" has three methods—sheet method, joint-frame method and cross-piece method. These three methods differ with materials used or time of construction and it is important to choose the suitable method. (See Table 1)

#### (1) Sheet method: (See Fig. 2 & 3)

Bricks and unit-bases bonded together at the factory are shipped to the construction site. They are easy

to be set in the mold and shorten construction work. This improvement reduces the cost of work on site.

#### (2) Joint-frame method: (See Fig. 4, 5 & 6)

Bricks and joint-frame units (styrol or gum) are shipped separately to the construction site. First joint-frames are set in the mold and then bricks are placed in the frame. Joint-frame units can be easily transported and handled on site. This method is recommended for facing of ordinary buildings with header and stretcher-facing tiles.

#### (3) Cross-piece method:

Wooden or plastic strips corresponding to the horizontal joint are attached to the vertical side of the mold for the wall. Facing bricks or queen closers are then laid using the strips to line the joint.

### TECHNIQUE OF SITE-PREFABRICATED CONSTRUCTION

The traditional hand laying on site and the Site-prefabricated construction show the same finish after completion of buildings, but their methods are largely different and make great difference in materials, process and time of construction, works and performance. The following is the study of essential difference and speciality of Site-prefabricated construction compared with the traditional method.

The study of this construction is divided into two aspects: one of control and workability and the other of technique and performance. First, merits and demerits of control or workability are:

- |           |   |
|-----------|---|
| Merits:   | Skilled layers are not required.<br>Plasterers are not necessary.<br>Molds have a longer life.<br>Time to use scaffolding is shorter.   |
| Demerits: | Process becomes complicated.<br>Accuracy of mold influences the preciseness of construction.<br>Bricks or tiles should be ordered earlier.<br>Leaves a large quantity of scrap. |

The time of constructing the molds is increased since the tiles have to be laid in addition to the work of the car-

penters and ironworkers. The cross-pieces and other temporary materials have to be removed. Some of the tiles also have to be repaired. It is very important to control the construction process in order to achieve success.

The greatest merit of the Site-prefabricated construction is that there is less tile failures. From experimental results and examples of construction, this method provides higher bond-strength than hand-laying, except in special cases where there are faults in concrete works such as many bubbles. If concrete is cast properly, there will be no failure of tiles. As air does not touch concrete, it prevents neutralization and better durability is expected. If bubbles or broken tiles are repaired properly, efflorescence or frost damage will be prevented. It is necessary to pay attention to mix proportion and casting of concrete. Expansion joint will be an efficient countermeasure for prevention of cracks. As to tiles themselves, they should have enough flexural strength to bear the compressive load of cast concrete. Another important point is that the preciseness of the finished walls is influenced by mold works and molds should be built carefully so as not to permit deformation. Also calculation of strain in the design of building should allow safety factor. With consideration of the above mentioned problems, the following shows the flow of the actual construction. (See Fig. 7 & Table 2)

## FLOW OF SITE-PREFABRICATED CONSTRUCTION

### Mold-Plans

As prefabricated units or crosspieces are set on the inner surface of molds and concrete is cast, the preciseness of molds decides the quality of the completed walls. Therefore the mold plans and works are very important in this Site-prefabricated construction and manufacture and installation of molds should be highly precise. For layout of molds, the size to keep preciseness, weight and shape easy for shipment, installation or stripping and quality of mold materials should be examined.

### Installation of Outer Molds

In the case of divided casting, the bottom of outer molds are fixed by the metal hooks buried in the lower-storied wall with crosspieces after adjustment of level.

Molds should maintain a consistent level at their joint and should not have any stain or dust on them. The preciseness of installed molds should be adjusted carefully, and for difficult parts such as corners or pillars of the building, prefabricated units should be set in the mold in advance.

### Layout and Drawing Lines

After installation of outer molds, standard layout lines are drawn on the inner surface and layout of sashes or prefabricated units or crosspieces are drawn next. It is desirable to draw layout of each prefabricated unit at each process.

### Installation of Sashes and Expansion-joint Material

As a basic rule, expansion joints are placed at joints of concrete at each floor level in the horizontal direction and at corners, pillars and opening in the vertical direction, but it is desirable to place them at suitable places determined by the design and structure of each building.

### Installation of Prefabricated Units

Bricks and prefabricated units are inspected thoroughly at the factory, but they should be carefully stored on site and should not be stained nor broken.

#### (a) Sheet Units:

As bricks and unit base are set together to form a sheet unit at the factory in advance, it should be carefully installed. Sheet units are fixed by the air stapler (Hotchkiss) at space of 200–300mm according to the layout lines. They should be placed precisely not to have any difference at edges of units and handled with care so that bricks or jointing pieces do not come off from units or the unit base does not float in the mold. First fix quoin units (corners and around openings) and fix standard units next.

#### (b) Joint-frame Units:

Units are fixed by the air stapler at space of 200–300mm according to the layout lines. They should be set precisely not to occur irregular joint line at edges of units.

Quoin units (corners and around openings) are installed first and standard units are installed next. Quoin units are manufactured on site. They should be well protected from rain.

### Installation of Crosspieces and Bricks

Crosspieces are installed to the mold according to the layout lines. As the bottom of bricks stay on these crosspieces, the level of crosspieces should be precise. Vertical crosspieces are set at every other rows of bricks and joint material such as urethane or styrol are placed in between for adjusting size. Bricks are layed along crosspieces with double-sided binding tape on the face of bricks. After laying bricks, joint mortar is poured and joint is treated to prevent flow out of concrete to the surface of bricks.

### Fastening of Metal Ties and Anchors

Protectors and separators are fixed in the indicated places. Form ties should be fastened evenly not to concentrate at one place.

### Reinforcing Works and Installation of Inner Molds

As a basic rule, reinforcing steel bars are installed after fixing of prefabricated units. Reinforcing bars should be installed carefully not to give any damage to bricks or prefabricated units. Separators and reinforcing bars should not be tied. After each cast of concrete the horizontal surface must be cleaned before the next inner mold



is installed so as to provide a good joints for the next casting.

### Curing

From installation of outer molds till concrete casting, molds and prefabricated units and bricks should be well protected from rain. After casting concrete, and mold stripping, covering by vinyl sheets is recommended for protection of the finished surface of bricks.

### Casting Concrete

Concrete of indicated mix proportion should be cast carefully not to damage bricks or prefabricated units. To ensure that the joints are filled, the concrete should be vibrated by hammering the outside of the mold with a wooden hammer and the inside mold either with a wooden hammer or a vibrator. Casting must be completed before vibrating takes place.

### Removal of Prefabricated Unit Bases

After stripping the mold, unit bases should be removed immediately and disposed. After removal of bases, concrete or stain on the brick surface should be cleaned as quickly as possible.

### Repair, Cleaning and Finish

Defects in brickwork and gaps where temporary materials have been removed are repaired by replacing with bricks. Joints are then pointed. When laying these bricks course level should be carefully maintained.

### FUTURE DEVELOPMENT OF SITE-PREFABRICATED BRICK CONSTRUCTION

During the ten years since this method was first developed, it has gained very high reputation for construction of public buildings, housing and various buildings on a large scale.

At present, necessary standards of quality of tile units and each construction process is being established through total investigation and experiments. Site-prefabricated construction has passed the cradle period, and now, is open for general utilization. Though manuals are published and working standards are established, stagnancy of technical improvement or easy-going control of works should be admonished.

Considering that eagerness in the technical improvement and careful control of works and accumulation of experiments at almost every construction site led this method to success, constant and modest efforts should be continued for better mold making and concreting techniques.

There are many subjects to be improved in the future, including fundamental study of tile-laying and comments are welcomed for technical development of prefabricated construction.

**TABLE 1—Classification of “Site Prefabricated Tile Construction”**

	Kinds of bricks		Prefabricated Unit Base	Binding of prefabricated units and bricks	Joint material and joint finish
	Sheet Method	Tile-type bricks of 20—25mm	Polyurethane Craft paper Backing veneer Chloride vinyl Polypropiren Polyesther	Binding sheet Binding agent starch synthetic resin binding agent	Plastic formation Plastic form Polyurethane Grout joint finish
Site Prefabricated Construction	Joint-frame method	Tile-type bricks of 20—25mm	Synthetic gum Synthetic resin	Craft paper + double-sided binding tape	Stylofoam Grout joint finish
	Crospiece method	Queen crossers Facing bricks	—	—	Crosspieces Pointing finish from back

TABLE 2—Standard Construction Time of Site Prefabricated Construction

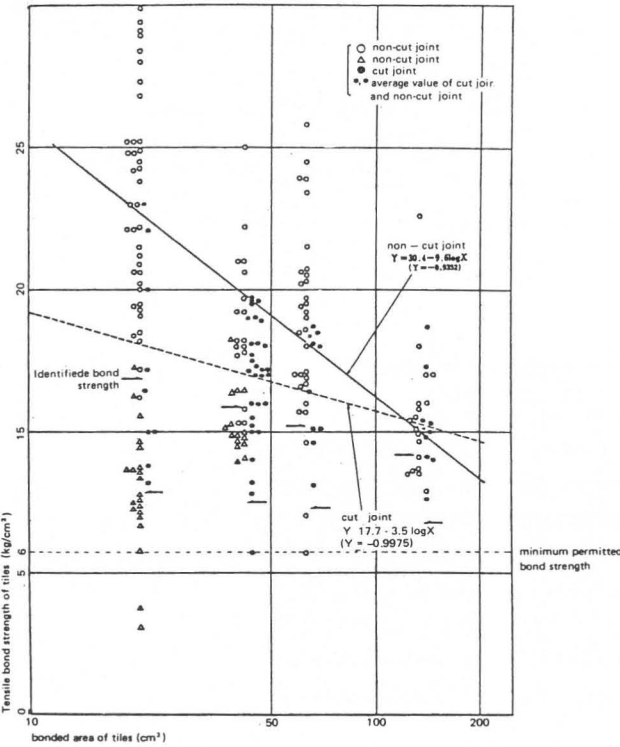
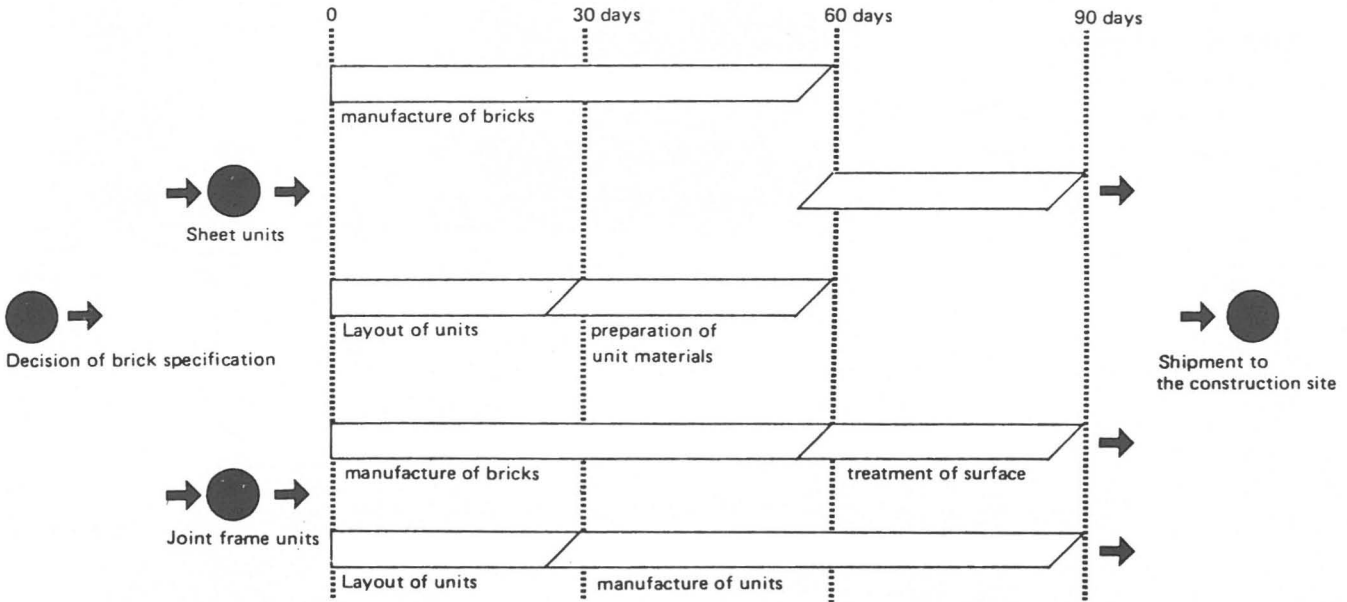


Figure 1. Relation between size of tiles and bond strength

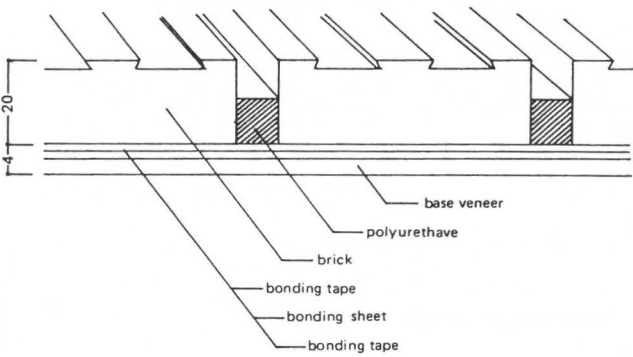


Figure 2. Sheet method

## standard joint measurement

vertical joint	8	10	12mm
horizontal joint	8	10	12mm
depth	10	12mm	

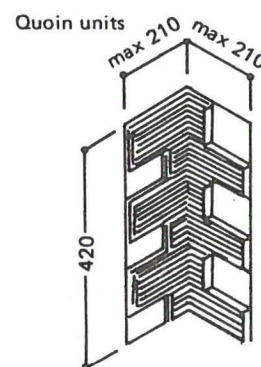
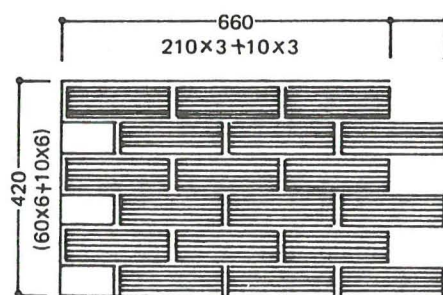


Figure 3. Standard size of sheet units

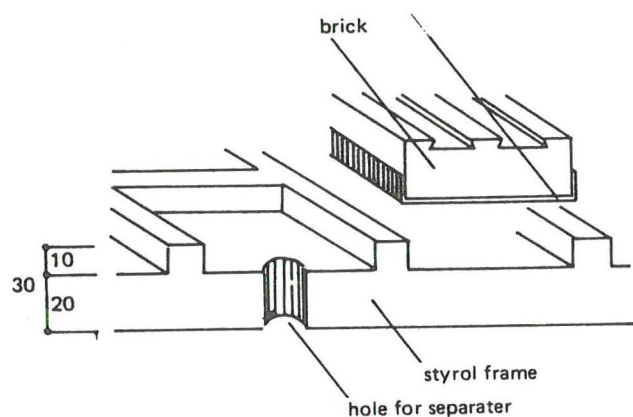


Figure 4. Joint frame unit (styrol)

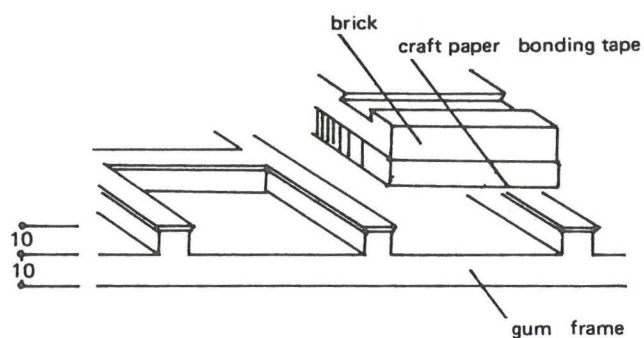
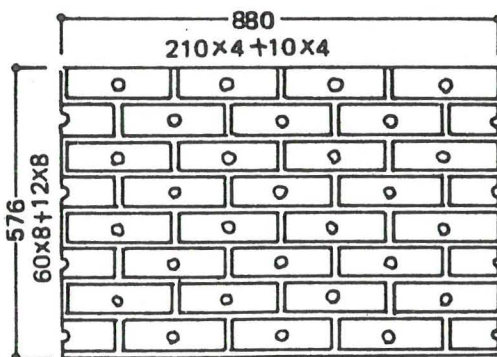


Figure 5. Joint frame unit (gum)

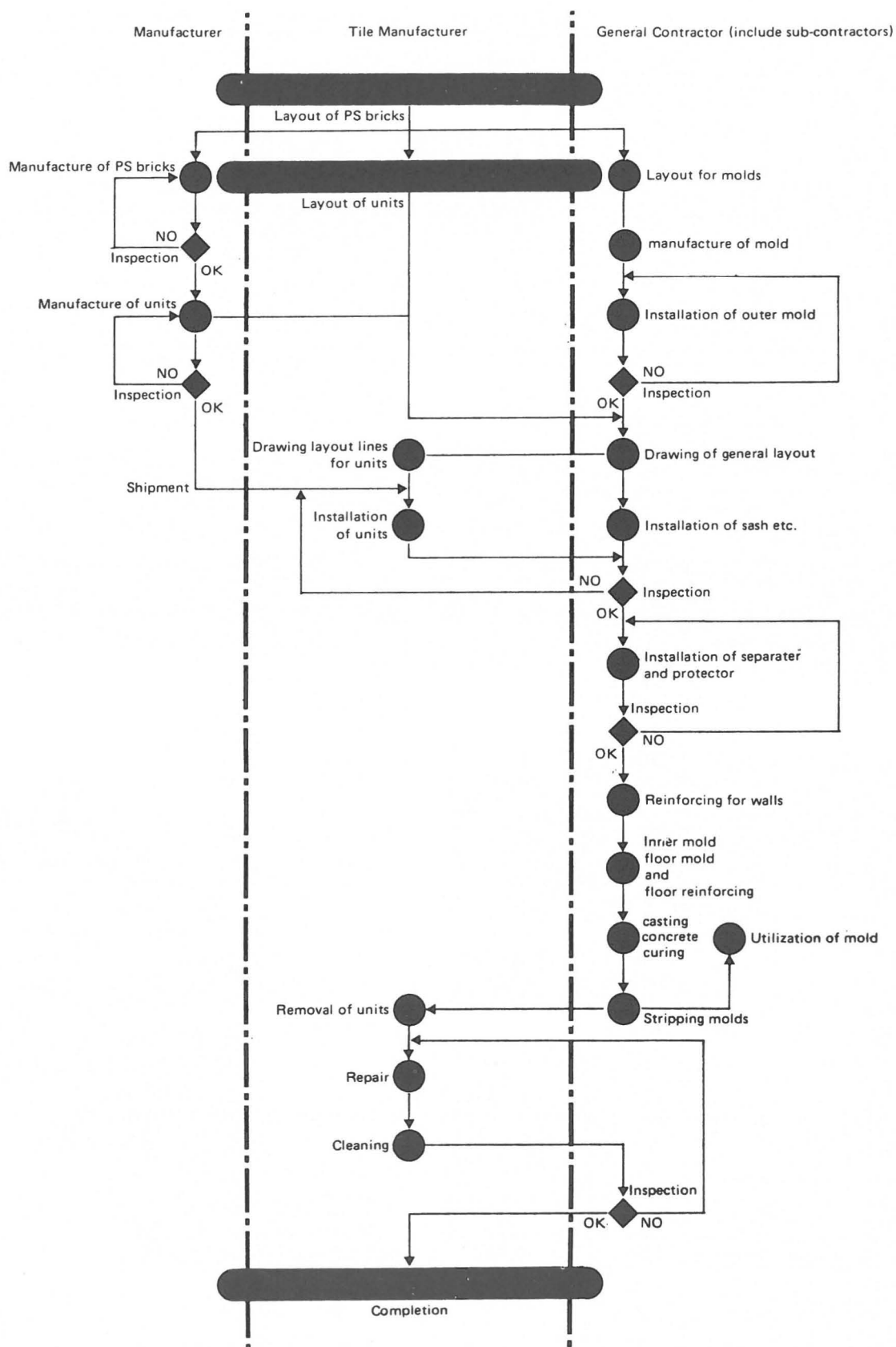
## joint measurement

vertical joint	10mm
horizontal joint	12mm
depth	10mm

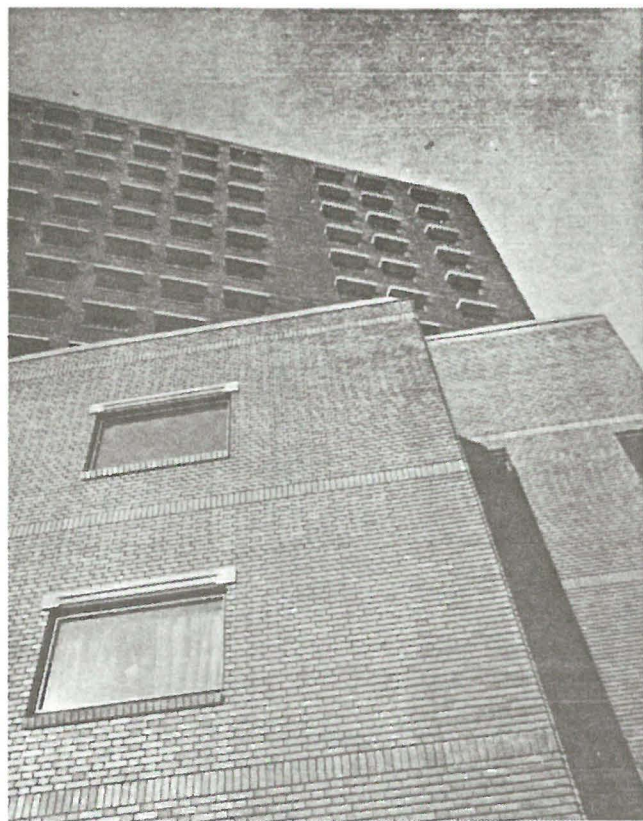


manufactured in site

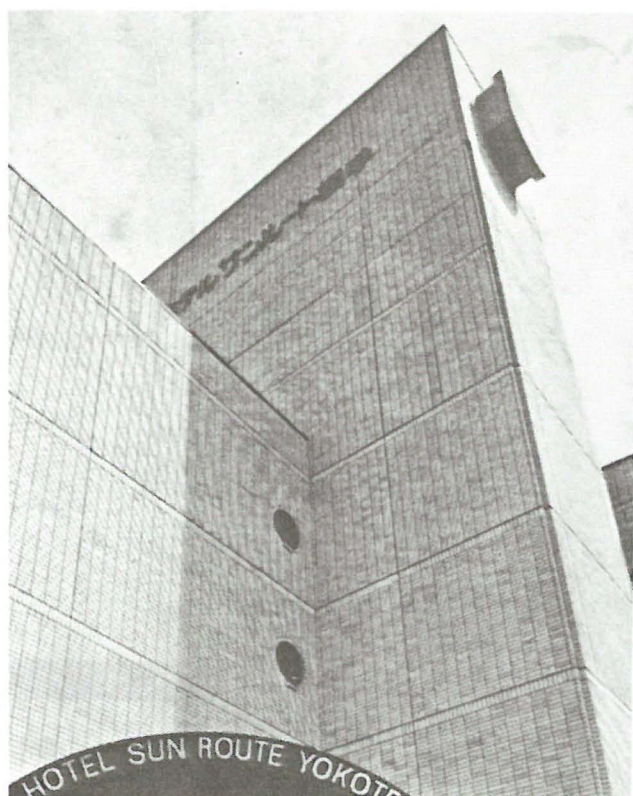
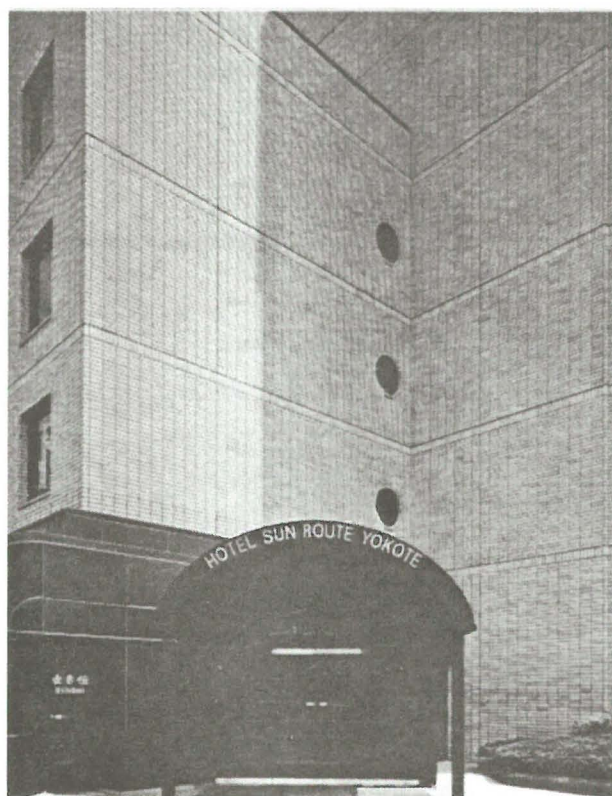
Figure 6. Standard size of joint frame units







*Example 1.* Plaza Umeshin



*Example 2.* Sun—Route Hotel Yokote