Group # 1

Site Cast Flat Slab Construction

Members :

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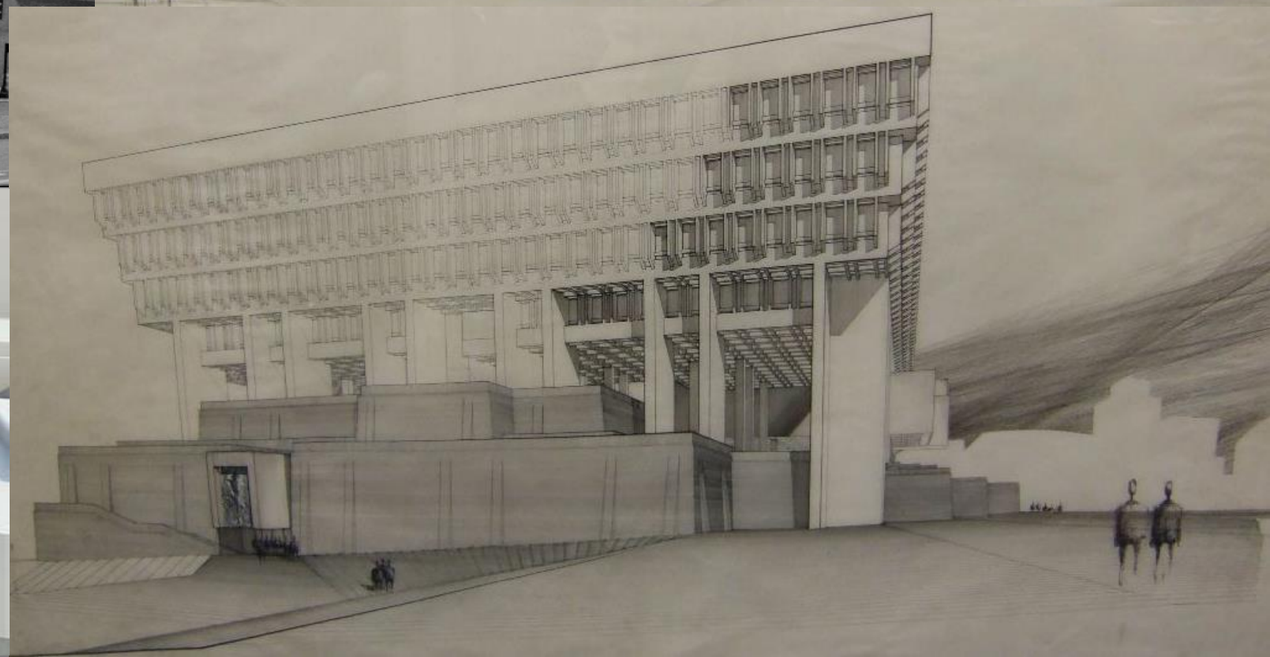
Boston City Hall



System Spans and Effective Spans

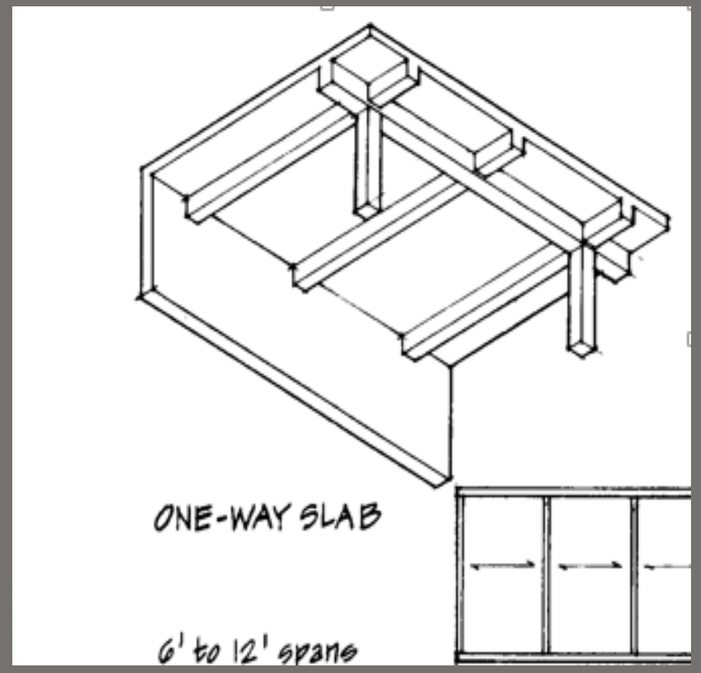
Construction Time and Cost

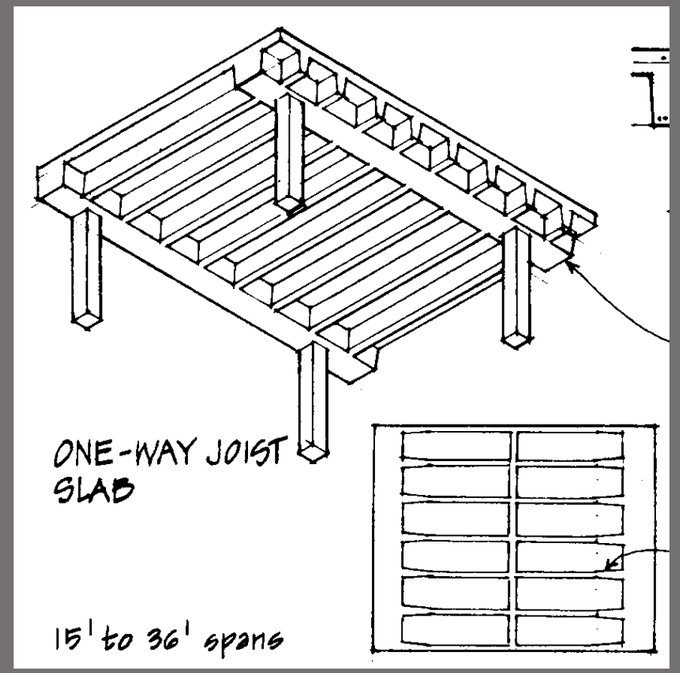
Architectural Finishes Available

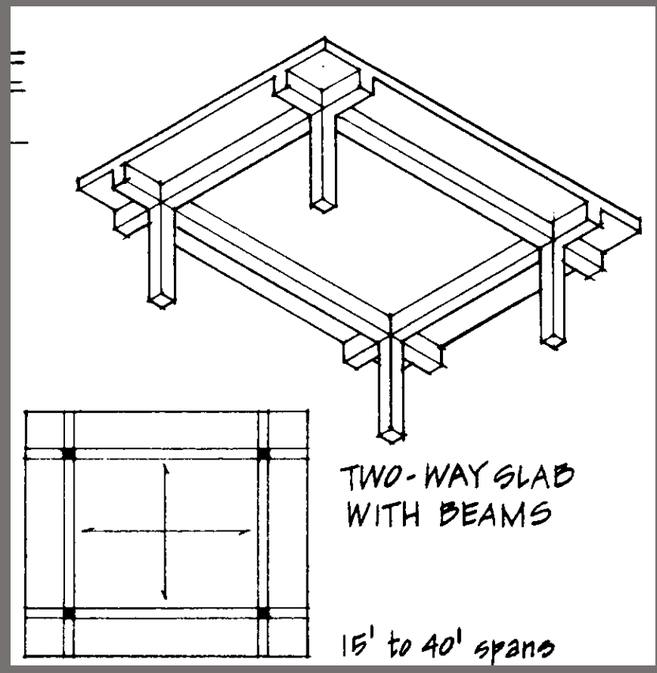
Flexibility of The Systems

Connection Details

Systems Strength and Weakness







One way slabs are designed to transfer their loads to only two opposite support walls.

Suitable for light to moderate loads over relatively short spans of 6’ to 18’

Effective Span: This is the distance between center of two opposite supports. In the case of one way slab the pair of opposite supports with shortest distance between them are taken as the supports.

- **One way joist slab** is designed as a series of T-beams, joist slab are more suitable for longer spans and heavier loads than one-way slabs.
- Suitable for light to medium live loads over spans of 15’ to 36’
- 5” to 9” joist width

- Two way slab and beam is effective for medium spans and heavy loads, or when a high resistance to lateral forces is required.
- Suitable for light to medium live loads over spans of 15’ to 40’.
- 4” min slab depth.
- Is more efficient when spanning square or nearly square bays. Suitable for carrying intermediate to heavy loads over 15’ to 40’ spans.

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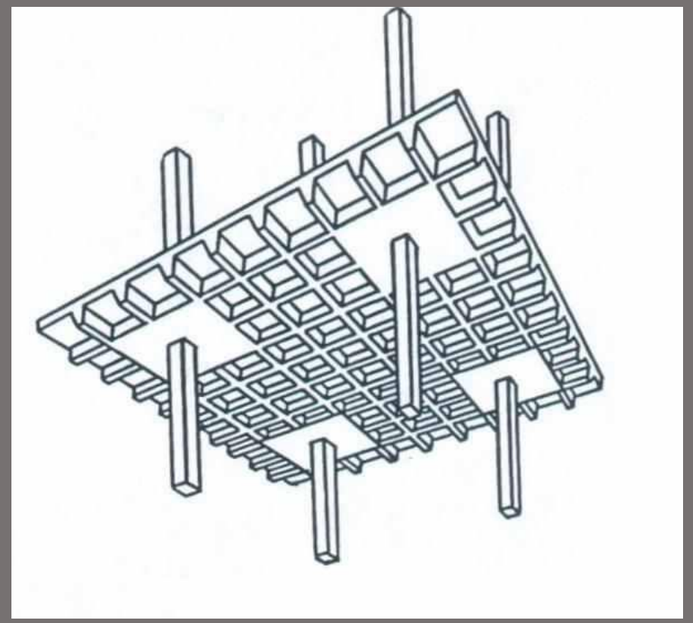


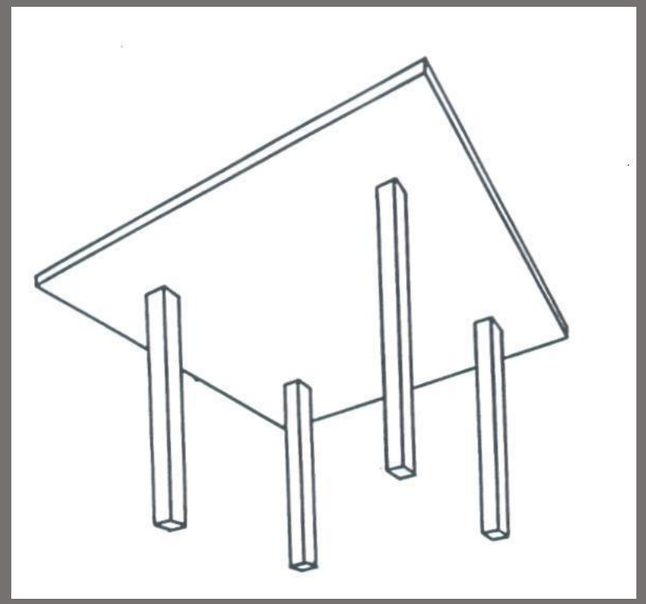
two way waffle slab is two-way concrete slab reinforced by ribs in two directions.

Waffle slabs are able to carry heavier loads and span longer distances than flat slabs.

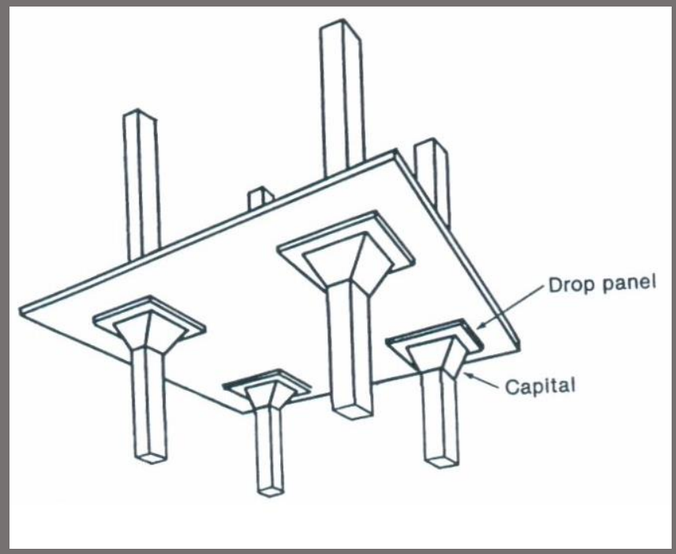
3” to 4 ½” slab depth.

5” to 6” rib width.

Suitable for spans of 24’ to 54’; longer spans can be possible by the use of posttensioning.



- **two way flat plate** is a concrete slab of uniform thickness reinforced in two or more directions and supported by columns without beams or girders. Practical for apartments and hotel construction.
- 5” to 12” slab depth
- Suitable for light to moderate loads over relatively short spans of 12’ to 24’



- **two way flat slab** is a flat thickened at its column supports to increase its shear strength and moment resistance capacity.
- 6” to 12” slab depth
- Suitable for relatively heavy loads and spans from 20’ to 40’
- Minimun width projection of drop panel: 0.24x slab thickness
- Minimun width of drop panel: 0.33 span

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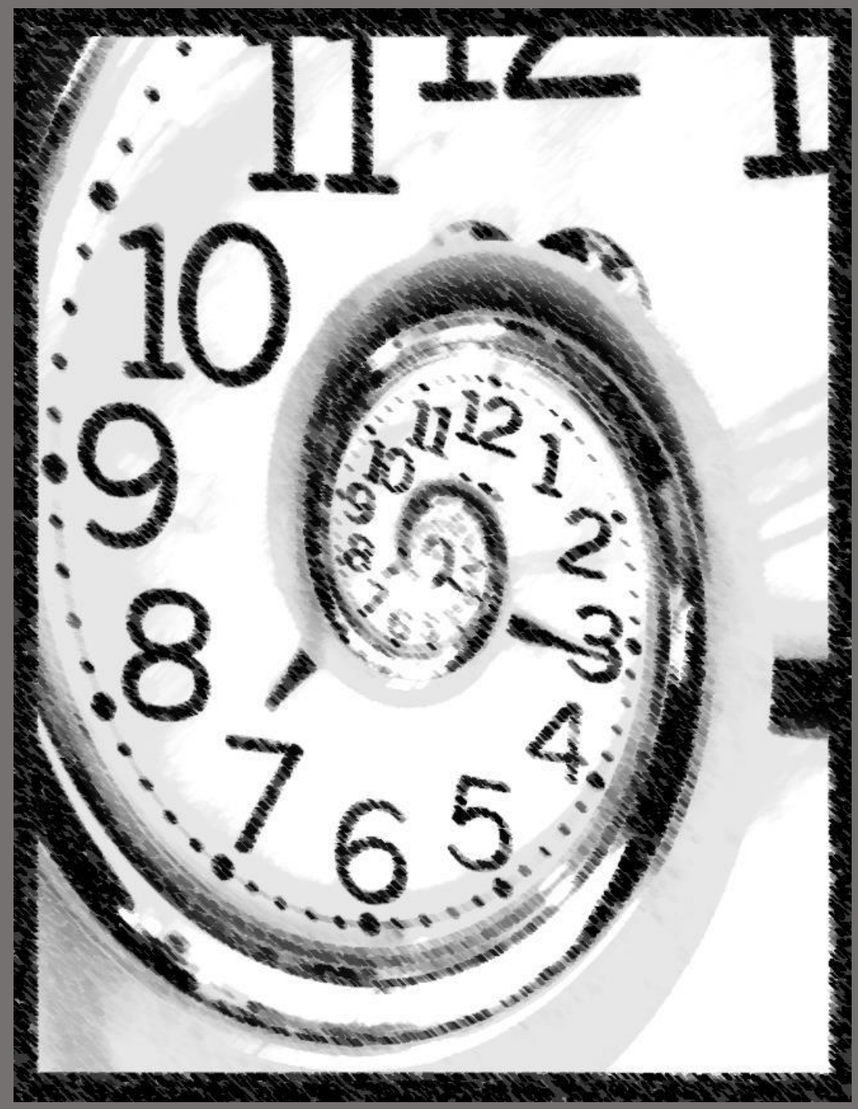
The control of time is one of the basic goals of all parties involved in a construction project. From the initial concept, the owner is interested in the time it takes for the finished project to be delivered. The owner's goal is to shorten the time it takes for each phase of the project'--from initial planning through construction execution. , Time is money. The economic significance of time is what prompts the owner to use the words "time is of the essence" in a contract. There are many facets of the construction process in which time can be directly controlled by the owner. With other elements, the owner can only exercise indirect control over time--usually with contract clauses and contracting procedures. "-The contractor is in the best position to exercise the most direct control over the duration of the construction phase. The network schedule is used by the contractor for project control; however, the duration of the project is usually a condition of the contract between the owner and the contractor. The owner may specify the contract duration based on economics, It is not until after signing the contract that the contractor generates a detailed network schedule. After development of the schedule, the contractor may find it necessary to shorten, or "compress" the construction time. The initial schedule's duration may be longer than the time required in the contract and adjustments must be made to satisfy contract provisions. The contractor may want to finish the project early to take advantage of bonus payments, to avoid the winter season, or to free up resources for other projects. In addition, the contractor may fall behind schedule during construction, requiring action to get back on track. In these instances, the contractor needs to determine the project duration at which construction costs are minimized. weather considerations, or some reason.



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SCHEDULE COMPRESSION TECHNIQUES

Schedule compression can be defined as "the shortening of the required time for accomplishing one or more engineering, procurement, construction, or startup tasks (or a total project), to serve one of three purposes: reducing total design-construct time from that considered normal; accelerating a schedule for owner convenience; and recovering lost time after falling behind schedule" Compression techniques are easiest to apply in the project planning phase, such as when the construction schedule--as initially planned--is longer than the proscribed contract duration. The project manager can compress the schedule before construction is started. Compression becomes more difficult if necessary to get a project back on schedule after it has fallen behind. The project manager is under a great deal of pressure and often does not have the time to apply the most cost effective techniques for compression. The Construction Industry Institute has cataloged more than 90 compression techniques, grouped into eight different categories: Ideas Applicable to All Phases of a Project, Engineering Phase, Contractual Approach, Scheduling, Materials Management, Construction Work Management, Field Labor Management, and Startup Phase. Some techniques shorten an activity's schedule time while others prevent needless time losses associated with project activities or management actions. A summary of these techniques follows . Ideas Applicable to All Phases of a Project Sound management practices can reduce the project time through all phases, from inception to completion of construction. The management organization must be well defined and staffed efficiently. The organizational structure should clearly establish all reporting, communication, and control lines. Narrative position descriptions that delineate the authority, responsibility, and accountability of each position must be maintained. Organizational clarity can reduce the potential for delays caused by confusion over who is responsible for what, who needs to be informed, and when. Excessive layers of line management should be avoided. Excessive layering usually produces conflicting instructions and unnecessary filtering of information and reviews that add extra time to task accomplishment.

A personnel management system that uses job descriptions, selective recruiting or hiring, performance appraisals, performance incentives, orientation, and training will ensure that the people hired are the most capable for managing and performing the work. Good personnel management practices can avoid delays caused by having the wrong people in the job.

The use of participatory management systems such as Deming's Total Quality Management can help reduce delays by training workers' ideas for reducing inefficiencies and increasing productivity. Possible techniques include delay surveys, quality circles, work studies, problem solving teams, suggestion programs, and worker discussions. When considering participatory management techniques, it is important to use them within the framework of the organization. Care must be taken to ensure that these techniques do not undermine the decision making authority of managers as

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TIME VERSUS COST

There are two classifications of costs associated with construction projects, direct costs and indirect costs. Direct costs include the labor, material and equipment operating costs necessary to put work in place. Indirect costs include supervision, job and home office overhead, profit, financing, and the cost of inflation. Direct costs can be allocated to each activity on the project. Indirect costs, on the other hand, can not be realistically prorated and assigned to each separate activity. Indirect costs add up continuously throughout the duration of the project, and if a CPM or precedence network is used for scheduling, can not be divided up among activities, some of which have float. Total indirect cost on a project increases with time as shown in Figure 3-1. This relationship is not necessarily linear. The actual shape of the curve depends on the complexity of the project and the types of indirect cost involved. Job overhead and general or home office overhead, a significant part of the total indirect costs, usually increase linearly with time as in Figure 3-2. These costs are normally assumed to be spread out over the entire project with a constant cost per day assigned; however, if the all overhead costs equally throughout the project duration,

the curve will not be linear and may have points of discontinuity.

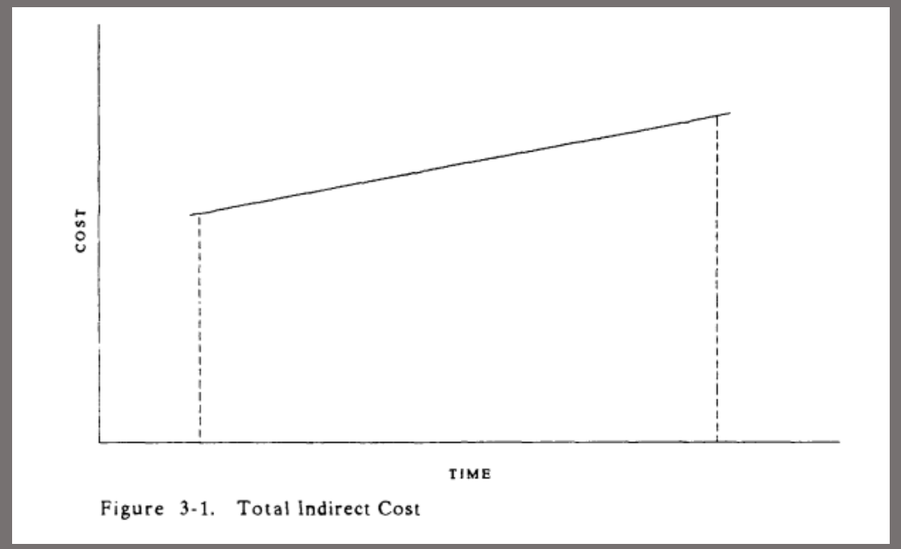

Figure 3-1. Total Indirect Cost

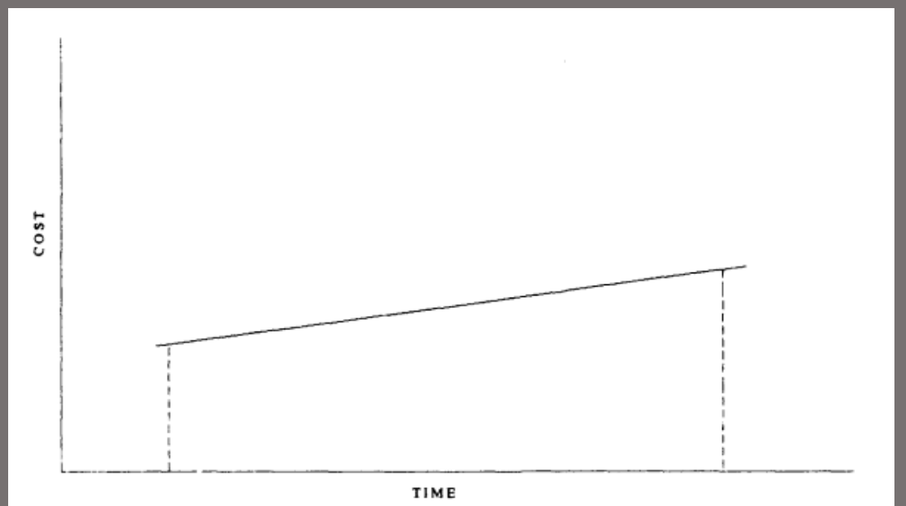

Figure 3-2. Job and General Overhead

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Most contractors must borrow money or use credit to finance construction costs. The cost of interest or finance costs increase with project time as shown in Figure 3-3. This relationship is not always linear--the shape will depend on the type of loan or credit extended and the repayment terms. Periodic loans or credit extensions made throughout the project will result in a curve with points of discontinuity such as the one in Figure 3-4.

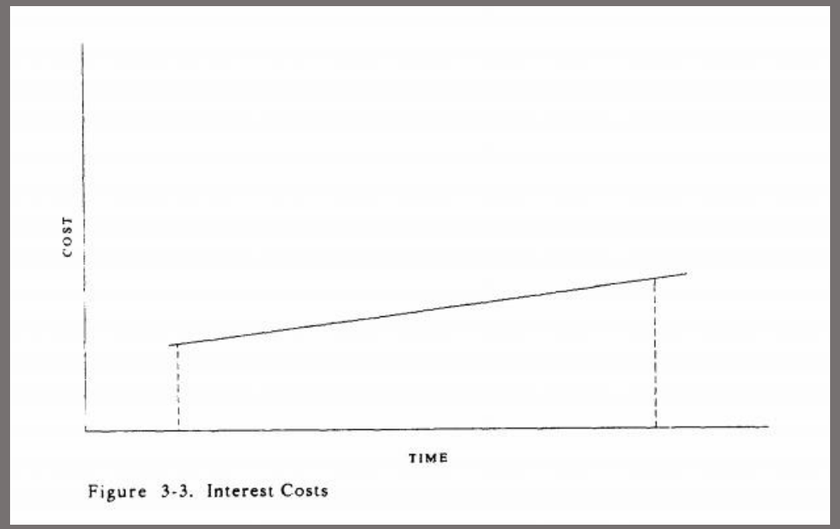

Figure 3-3. Interest Costs

If the contract specifies liquidated damages or penalties for late completion or bonuses for early completion, the cost of the project as a function of time is effected as shown in Figure 3-5 and Figure 3-6.

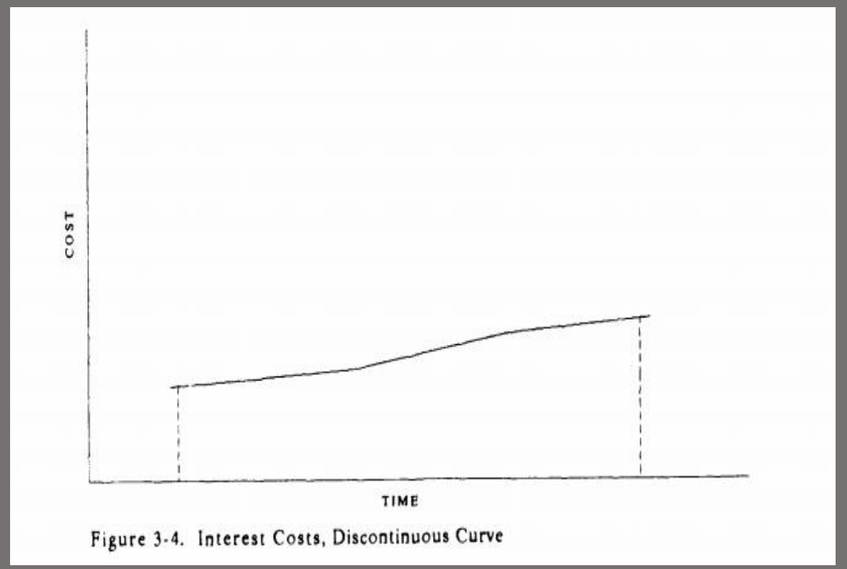

Figure 3-4. Interest Costs, Discontinuous Curve

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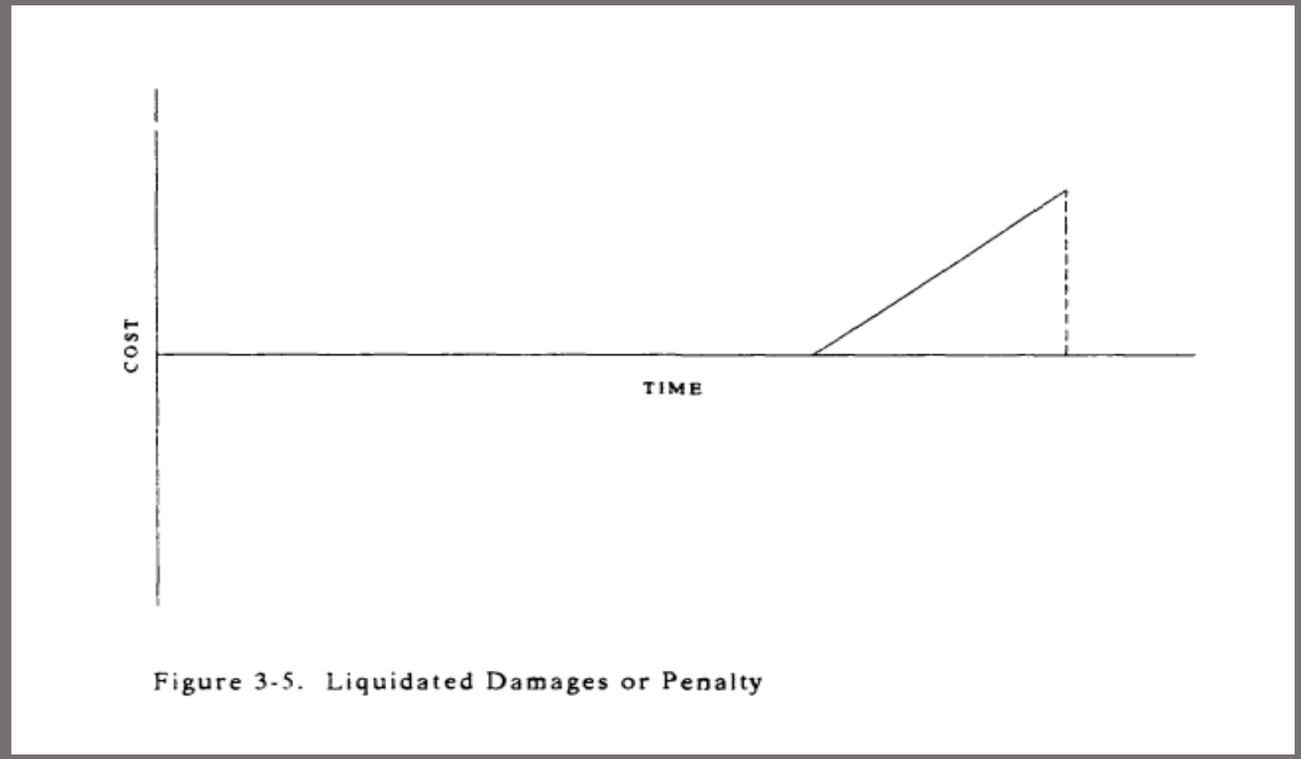

Figure 3-5. Liquidated Damages or Penalty

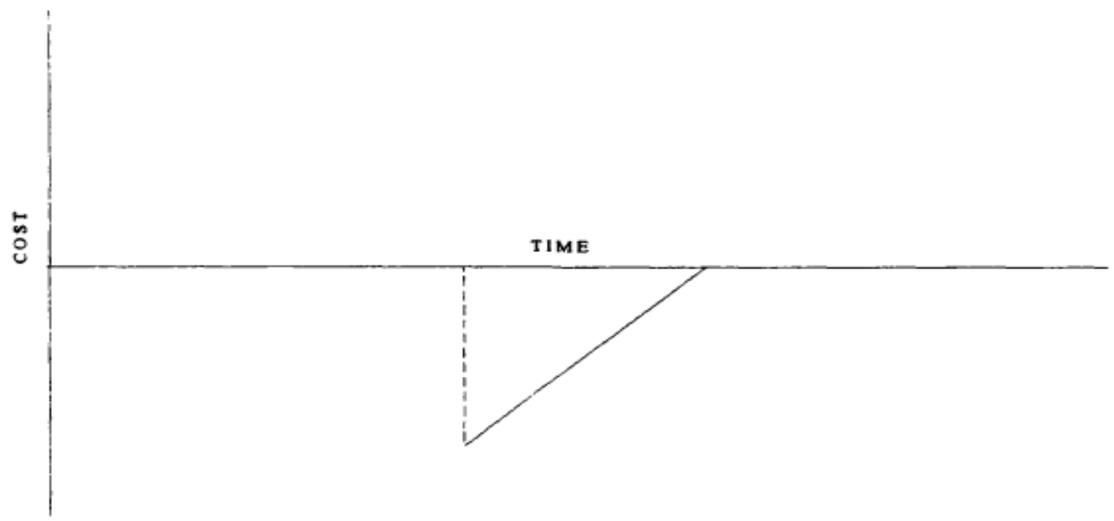

Figure 3-6 . Bonus

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Since the bonus is an additional payment to the contractor, it is shown as a "negative cost." Shapes of penalty and bonus curves may vary, depending on the particular contract provisions. The total direct cost will always decrease as project duration increases, as shown in Figure 3-7. Efforts to compress or "crash" activity completion time will result in higher direct cost for each activity.

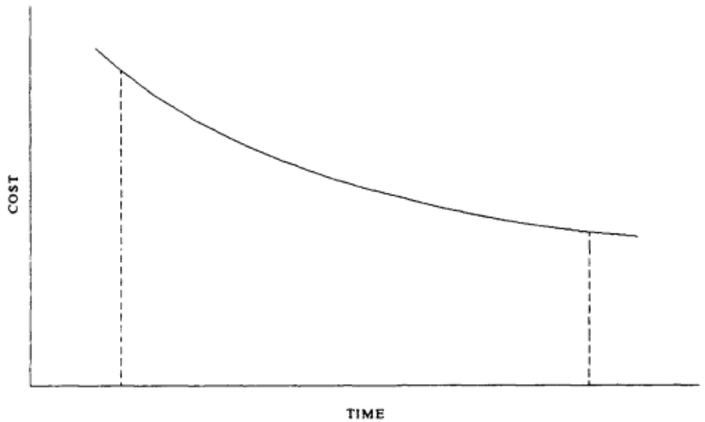

Figure 3-7. Direct Cost

Once curves for all costs and bonuses or savings are established, they are added together to yield a "Total Project Cost vs. Time" curve such as the one shown in Figure 3-8. The lowest point on the curve gives the lowest cost project duration. This duration may not be the "ideal duration." There may be other considerations within the company, not involving the project, that the project manager must take into consideration when selecting the ideal project duration.

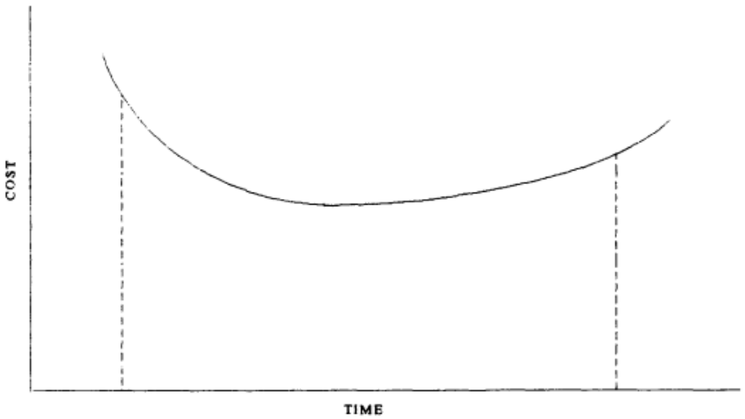

Figure 3-8. Total Project Cost

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Smooth Finish

After other concrete construction is complete in each overall separate contiguous area of the structure. Use a mortar mix consisting of one part Portland cement and two parts well graded sand passing a 0.6 mm No. 30 sieve, with water added to give the consistency of thick paint. Where the finished surface will not receive other applied surface, use white cement to replace part of the job cement to produce an approved color, which shall be uniform throughout the surfaces of the structure. After the surface has been thoroughly wetted and allowed to approach surface dryness, the mortar shall be vigorously applied to the area by clean burlap pads or by cork or wood-floating, to completely fill all surface voids. Scrape off excess grout with a trowel. As soon as it can be accomplished without pulling the mortar from the voids, the area shall be rubbed with burlap pads having on their surface the same sand-cement mix specified above but without any mixing water, until all of the visible grout film is removed. The burlap pads used for this operation shall be stretched tightly around a board to prevent dishing the mortar in the voids. The finish of any area shall be completed in the same day, and the limits of a finished area shall be made at natural breaks in the surface. The surface shall be continuously moist cured for 48 hours commencing immediately after finishing operations in each area. The temperature of the air adjacent to the surface shall be not less than 10 degrees C 50 degrees F for 24 hours prior to, and 48 hours after, the application. In hot, dry weather the smooth finish shall be applied in shaded areas or at night, and shall never be applied when there is significant hot, dry wind.

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Grout-cleaned finish

The surfaces of [_____] shall be given a grout-cleaned finish as described, as approved by the Contracting Officer and after all required curing, cleaning, and repairs have been completed. Surfaces to be grout-cleaned shall be moist cured for the required period of time before application of the grout-cleaned finish. Grout-cleaning shall be delayed until near the end of construction on all surfaces not to be painted in order to achieve uniformity of appearance and reduce the chance of discoloring caused by subsequent construction operations. The temperature of the air adjacent to the surface shall be not less than 5 degrees C 40 degrees F for 24 hours prior to and 72 hours following the application of the finish. The finish for any area shall be completed in the same day, and the limits of a finished area shall be made at natural breaks in the finished surface. The surface to receive grout-cleaned finish shall be thoroughly wetted to prevent absorption of water from the grout but shall have no free water present. The surface shall then be coated with grout. The grout shall be applied as soon as the surface of the concrete approaches surface dryness and shall be vigorously and thoroughly rubbed over the area with clean burlap pads, cork floats or stones, so as to fill all voids. The grout shall be composed of one part Portland cement as used on the project, to two parts by volume of well-graded sand passing a 600-µm (No. 30) sieve mixed with water to the consistency of thick paint. White Portland cement shall be used for all or part of the cement as approved by the Contracting Officer to give the desired finish color. The applied coating shall be uniform, completely filling all pits, air bubbles, and surface voids. While the grout is still plastic, remove all excess grout by working the surface with a rubber float, burlap pad, or other means. Then, after the SECTION 03 35 00.00 10 Page 10surface whitens from drying (about 30 minutes at normal temperature) rub vigorously with clean burlap pads. Immediately after rubbing is completed, the finished surface shall be continuously moist cured for 72 hours. Burlap pads used for this operation shall be burlap stretched tightly around a board to prevent dishing the mortar in the voids.

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Textured Finish

This type of finish shall be applied where specified to conform to details shown in the drawings by use of approved textured form liners. Liner panels shall be secured in the forms by methods recommended by the manufacturer but not by methods that will permit impressions of nail heads, screw heads, washers, or the like to be imparted to the surface of the concrete. Edges of textured panels shall be sealed to each other to prevent grout leakage. The sealant used shall be non-staining to the surface. The finish shall be similar to and shall closely match the finish on the sample panel.

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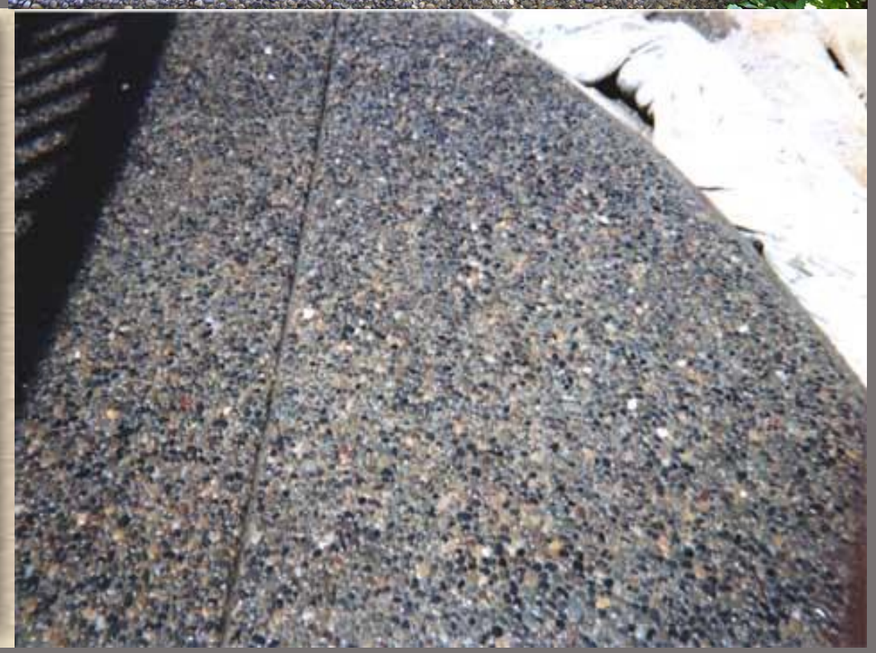
Exposed Coarse-Aggregate Finish

Coarse aggregate shall consist of [_____] material, shall meet the specified quality requirements, and shall have a grading as follows: [_____]. Expose coarse aggregate by an approved method. The finish shall be similar to and shall closely match the finish on the sample panel put on display during the bidding period, and the finish on the approved preconstruction test panel fabricated by the Contractor.



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Sandblast Finish

Blast the concrete surface at an approved age with approved wet sandblasting procedures to obtain a [brush] [light] [medium] [heavy] finish which will match the descriptive photographs in ACI 303R. The finish shall be similar to and shall closely match the finish on the approved preconstruction test panel fabricated by the Contractor.

Tooled Finish

The thoroughly cured concrete shall be dressed at an approved age with approved electric, air, or hand tools to a uniform texture with a [hand-tooled] [rough] [fine-pointed] [crandalled] [or] [bush-hammered] surface texture. The finish shall be similar to and shall closely match the finish on the approved preconstruction test panel fabricated by the Contractor.

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Flexibility for the occupier

- Flat slab construction offers considerable flexibility to the occupier who can easily alter internal layouts to accommodate changes in the use of the structure.

- This flexibility results from the use of a square or near-square grid and the absence of beams, down stands or drops that complicate the routing of services and location of partitions.

The benefits of using flat slab construction are becoming increasingly recognized. Flat slabs without drops (thickened areas of slab around the columns to resist punching shear) can be built faster because formwork is simplified and minimized, and rapid turn-around can be achieved using a combination of early striking and flying systems. The overall speed of construction will then be limited by the rate at which vertical elements can be cast.

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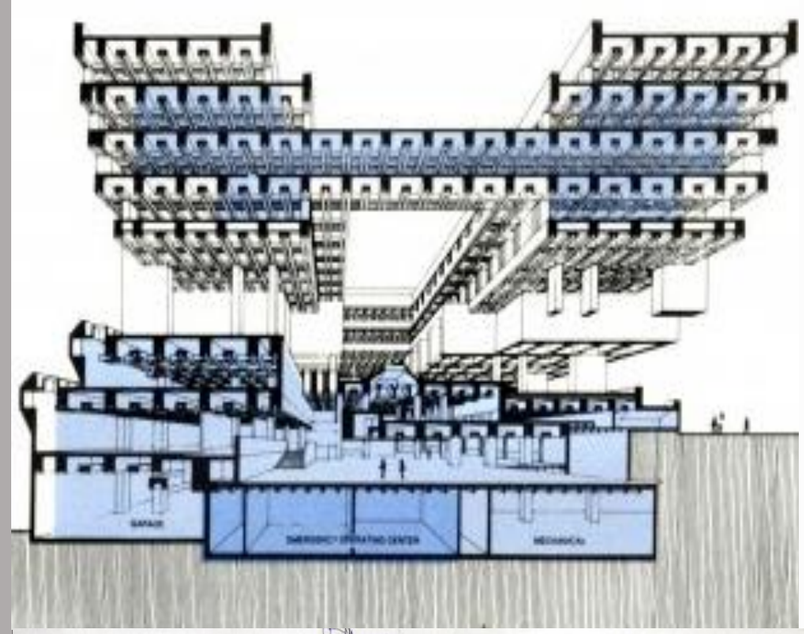
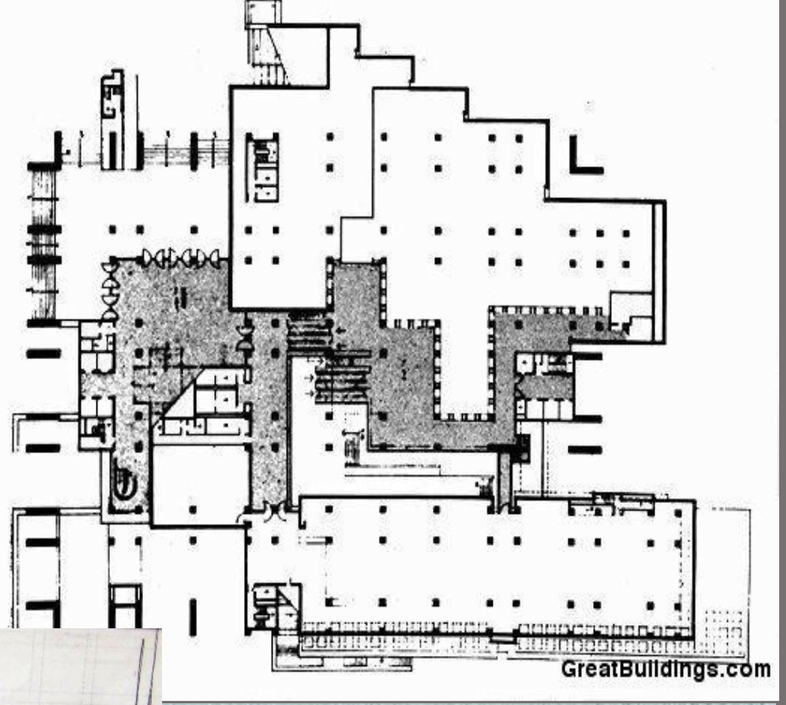
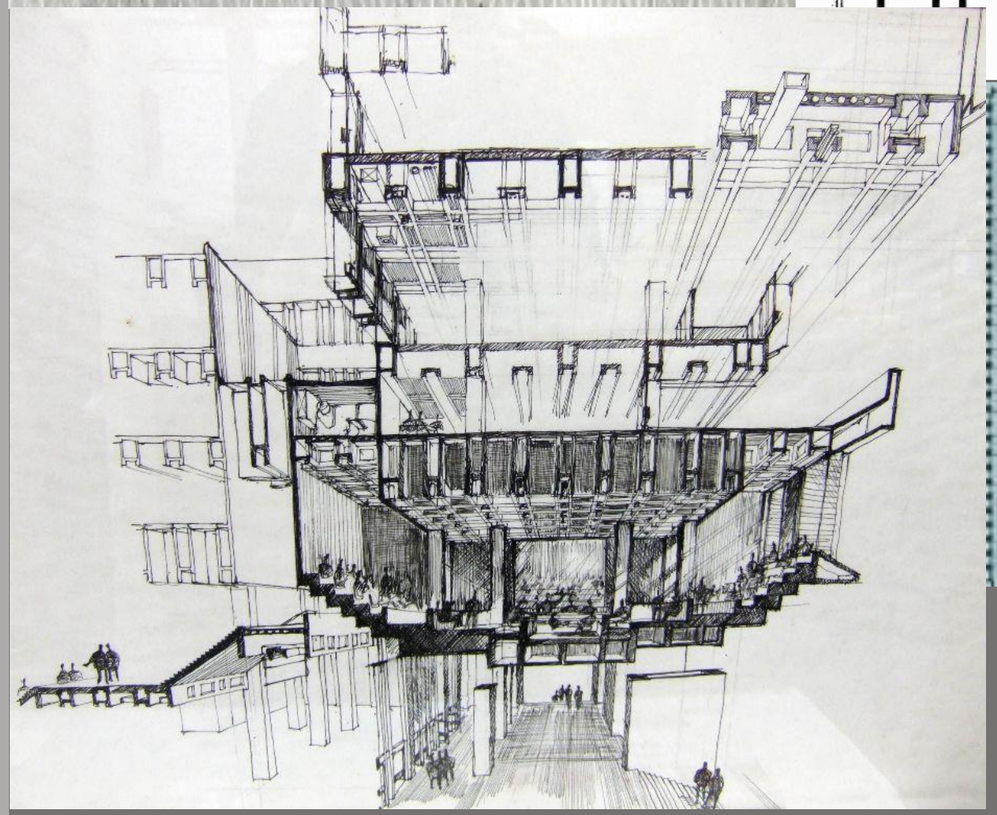
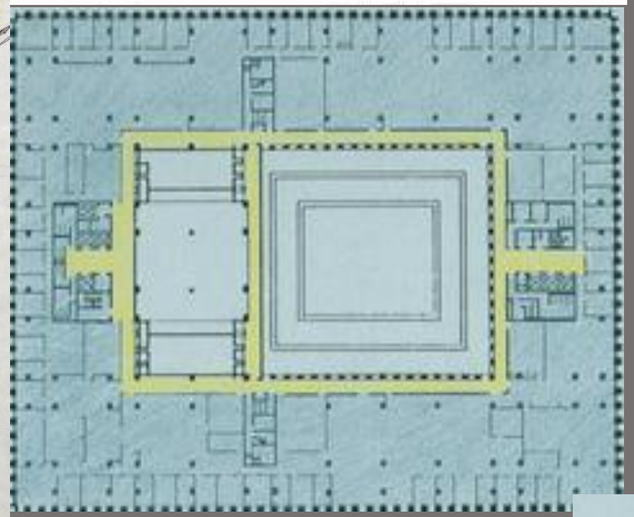




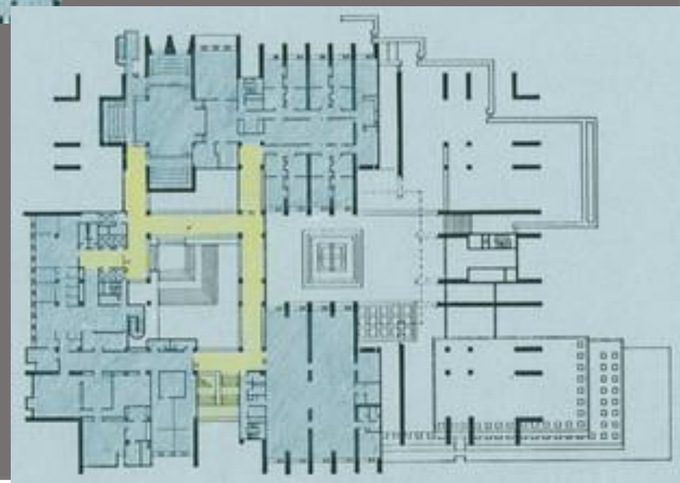




Reduced Services and Cladding Cost

- Flat slab construction places no restrictions on the positioning of horizontal services and partitions and can minimize floor-to-floor heights when there is no requirement for a deep false ceiling.

- This can have knock-on benefits in terms of lower building height, reduced cladding costs and prefabricated services.



Some design methods, in particular yield line, result in more rationalized reinforcement layouts than others. To overcome the misconception that opting for the least material necessarily results in lowest overall price, the benefits of rationalization need to be clear to all those involved in the process.

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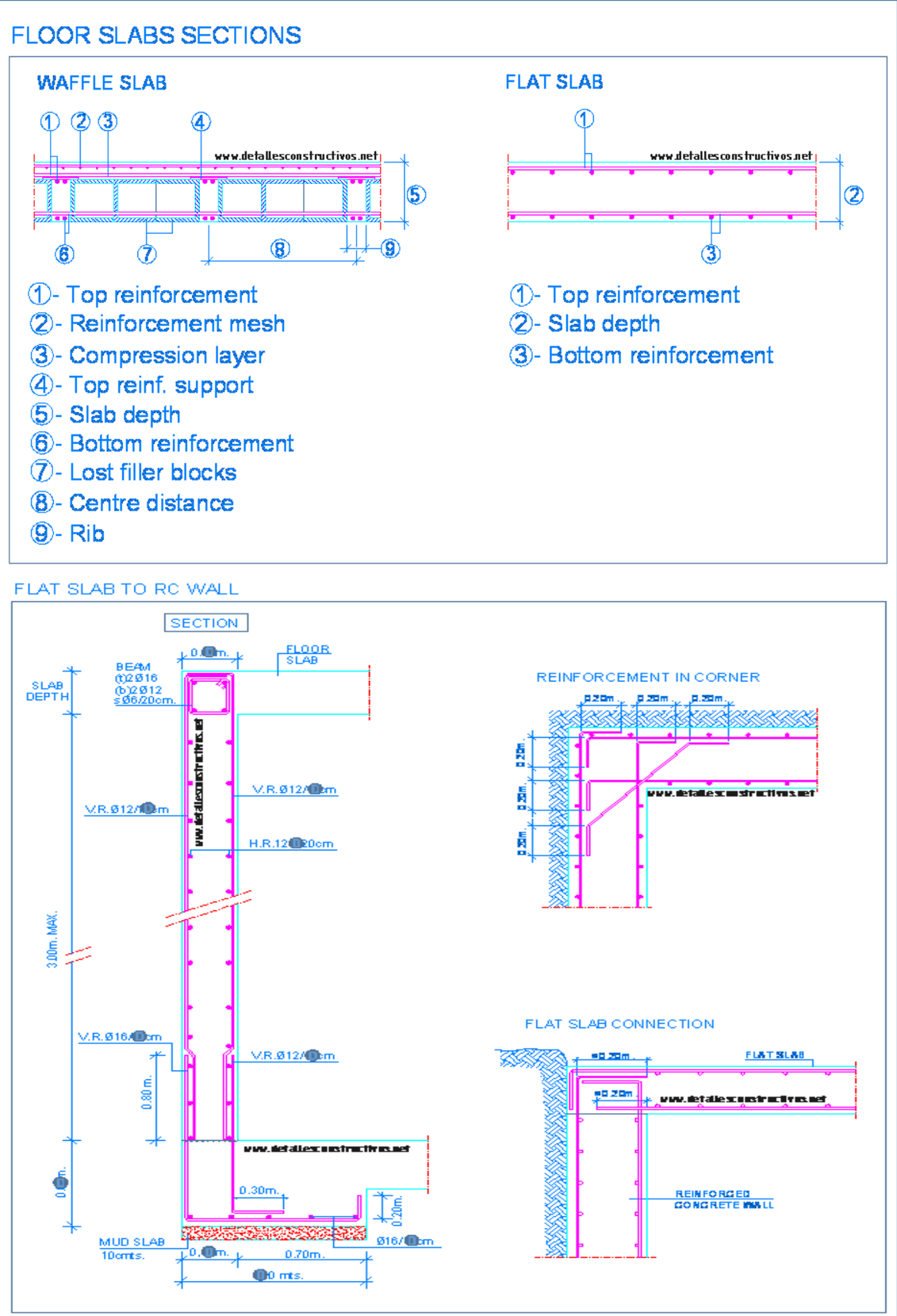

Construction Loads

- A high ratio of dead to live load is an inherent feature of flat slabs (and reinforced concrete construction in general). With the trend towards faster construction and lower design imposed loads, the ‘spare capacity’ of a slab over its self-weight is being reduced.

- Having chosen a flat slab solution, the next key issue is to determine an appropriate slab thickness. In general, thinner slabs not only save on direct material costs for the frame and the supporting foundations but also provide knock-on benefits in terms of reduced height of the structure and lower cladding costs.

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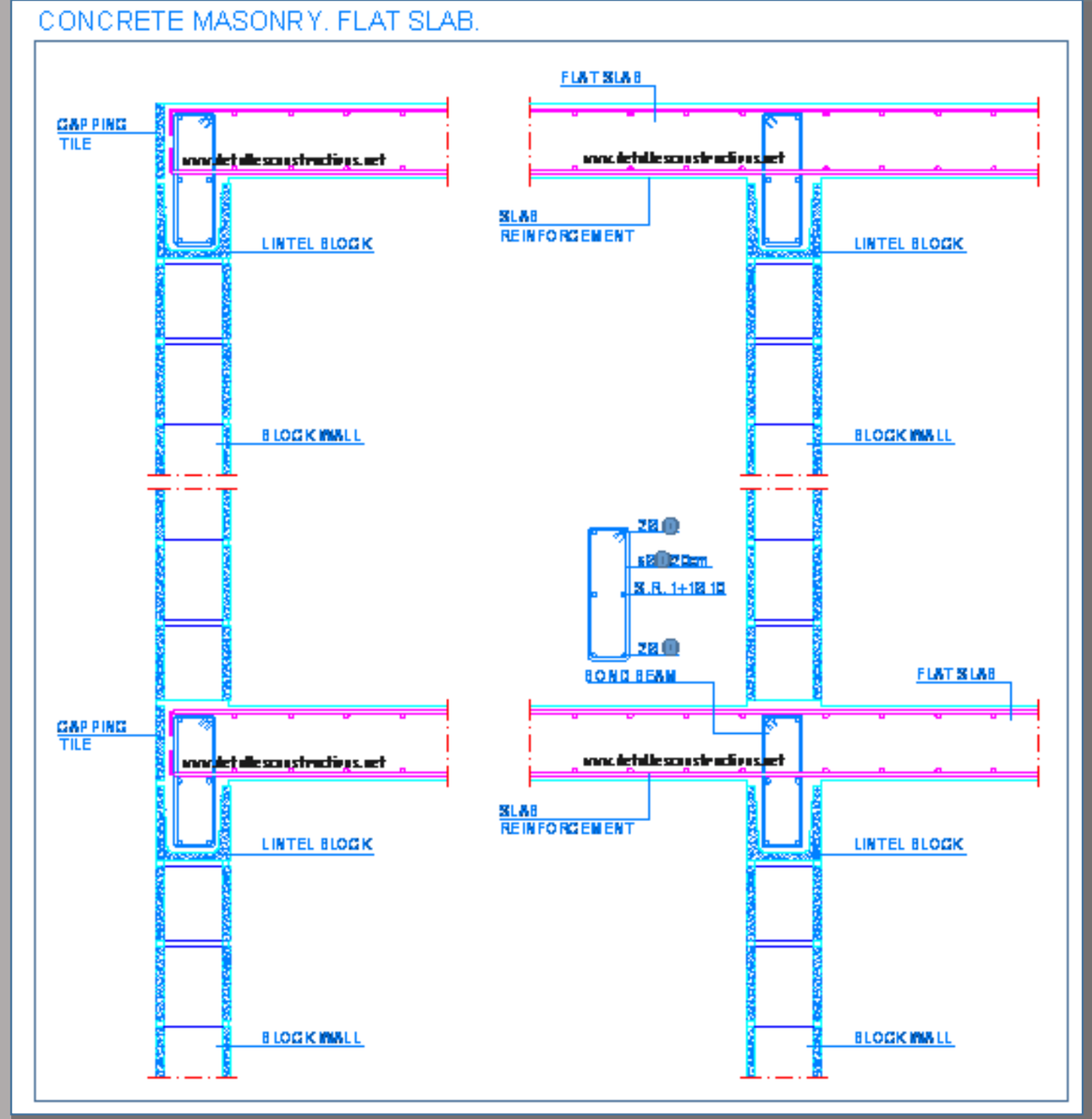
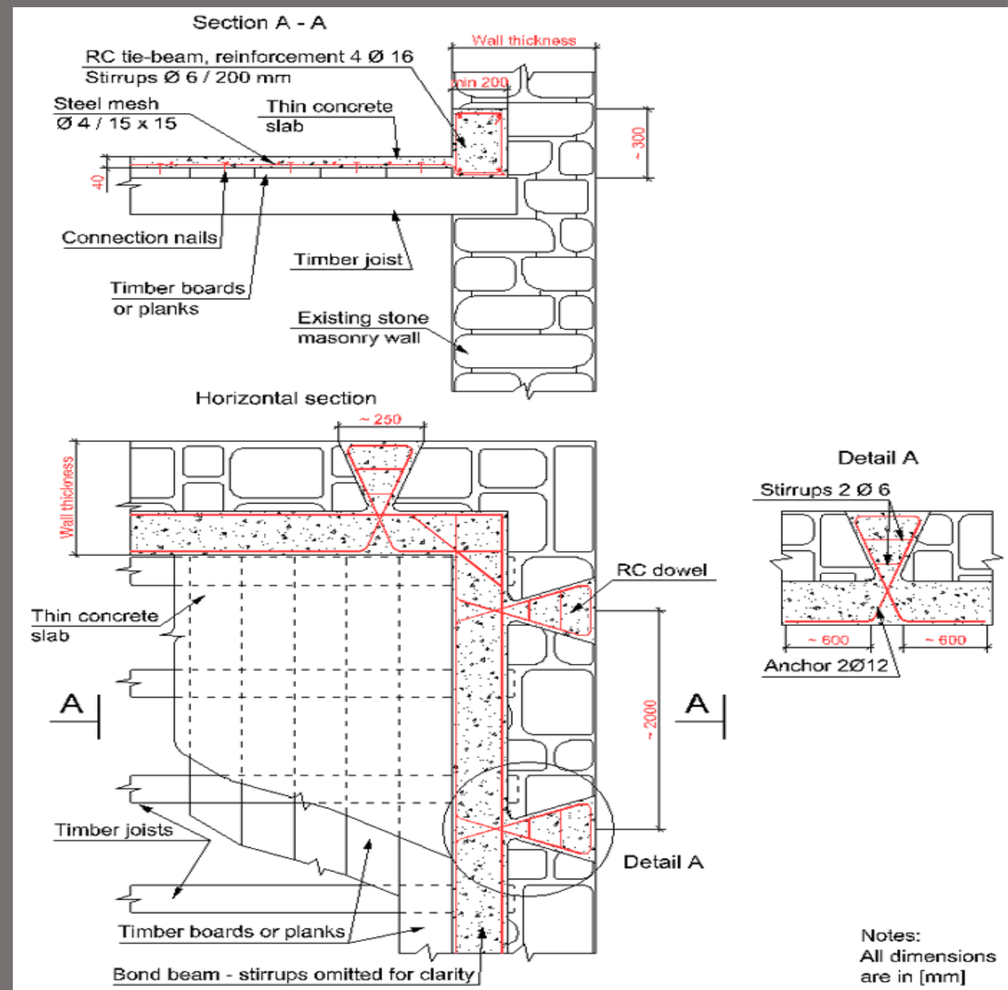


- In general, thinner slabs not only save on direct material costs for the frame and the supporting foundations but also provide knock-on benefits in terms of reduced height of the structure and lower cladding costs. There is, of course, a lower limit to the slab thickness.

Buildable Score

- Allows standardized structural members and prefabricated sections to be integrated into the design for ease of construction. This process will make the structure more buildable, reduce the number of site workers and increase the productivity at site. More tendency to achieve a higher Buildable score.



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Selecting a Site Cast Concrete Framing System

Factors to be consider for the selection of site cast concrete framing system for buildings.

1. Are the bays of the building square or nearly square? If so, a **two-way** system will probably be more economical than a **one-way** system.

2. How long are the spans? Spans up to 25’ or 30’ are usually accomplished most economically with a **two-way** at **plate** or **slab system** because of the relatively of the frame work.

For longer spans a **one-way joist** system may be a good choice. Po

3. How heavy are the loads? Heavy industrial loadings are transported better by thicker slabs an larger beams than they are by light joist construction.

Ordinary commercial, institutional, and residential loading are carried easily by **plate** or **joist system.**

4. Will there be a Nish ceiling beneath the slab? If not, at plate and one-way slab construction have smooth, paintable undersides that can serve as ceiling.

5. Does the lateral stability of the building against wind and seismic loads have to be provided by the rigidity of the concrete frame? Flat plate may not be sufficiently rigid for this purpose, which favor a one-way system with its deeper beam to beam connection.

Sources & Citations

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