

# ECONOMICAL CONCRETE CONSTRUCTION



A SERVICE OF THE CONCRETE REINFORCING STEEL INSTITUTE

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# CRSI

ENGINEERING  
DATA REPORT  
NUMBER 32

## INTRODUCTION AND PURPOSE

Rapidly-paced building construction is dictated by financing concerns. Building owners and developers want to minimize the high interest rate construction loan time period and press toward building completion so that revenue can be realized. In cast-in-place multi-story concrete buildings, a "typical floor" construction cycle of 5 to 7 days per floor is easily achievable and 2 and 3 days cycling is not uncommon in some areas.

How is a fast-paced construction cycle achieved? It's achieved through teamwork among the trades involved with the building superstructure. This team, comprised of the formwork contractor, rebar placer, HVAC, plumbing, and electrical subs, and the concrete placer/finisher, carries out a predetermined sequence of synchronized activities. Before this team can function, however, mutual agreement and understanding must be reached between the Formwork Contractor and the Engineer of Record. The Engineer of Record must come to an understanding of how the Formwork Contractor would like to use the newly completed segments of the structure to support formwork for the next floors in the cycle. At the same time, the Formwork Contractor must come to an understanding of what limitations the Engineer of Record has on the use of these newly completed segments of the structure as supports for the formwork of the floors to be cast.

The purpose of this report is to present state-of-the-art engineering information on rapid cycle concrete formwork methodology. This information should be useful for Formwork Contractors contemplating rapid cycle work and for Engineers whose projects are being considered for rapid cycle construction. Presentations that concentrate on the preplanning needed to devise the sequence of synchronized events that rapid cycling involves are available elsewhere. (1,2)\*

\* Numbers in parentheses correspond to references cited at the end of this report.

## FORMWORK SYSTEMS USED FOR RAPID CYCLE CONSTRUCTION

Formwork systems in use today for rapid cycle construction can be grouped into four general categories:

- 1. CONVENTIONAL AND GANG SYSTEMS** – these systems may be hand-set or panelized. Hand-set systems usually consist of wood shores or shoring supporting plywood-decked wood or aluminum framing. Segments of deck forms can also be made into ganged panels supported by pre-attached shoring frames.
- 2. FLYING TRUSS SYSTEMS** – these systems use steel or aluminum trusses to support plywood-decked wood or aluminum framing. Adjustable vertical members support the trusses off a previously cast deck. The truss-mounted forms are moved between casting positions by crane.
- 3. COLUMN-MOUNTED SHORING SYSTEMS** – these systems are large deck panels with framing members that span between in-place columns or bearing walls with no intermediate vertical shoring. Brackets or screw jacks, anchored to the in-place columns or walls, support the panel perimeter framing which is quite often structural steel beams. The panels are moved between casting positions by crane.
- 4. TUNNEL FORM SYSTEMS** – these systems are factory-made U-shaped steel forms which permit casting of a slab and the adjacent supporting walls at the same time. When sufficient concrete strength is developed, the forms are collapsed or telescoped and moved to the next placement location.

Of these four, conventional and flying truss systems are most often used for rapid cycle work. Both of these systems transmit the weight of newly-placed concrete to the most recently cast floors below. For sake of comparison, consider a common shore/reshore cycle used in multistory construction.

The interconnected assembly consists of several slabs, one or two levels of shores and a number of sets of reshores. One commonly employed construction sequence involves four phases in each casting cycle. See Fig. 1. The first phase is casting of a new floor. In the second phase, the lowest story of reshores are removed. In the third phase, the lowest story of shores are removed. The fourth phase involves installation of reshores in the story vacated in phase three. The combination of shores and reshores provided must be such that the applied construction loads (generated by the casting of a new slab) do not exceed the capacity of the interconnected slabs or induce excessive deflections. (3)

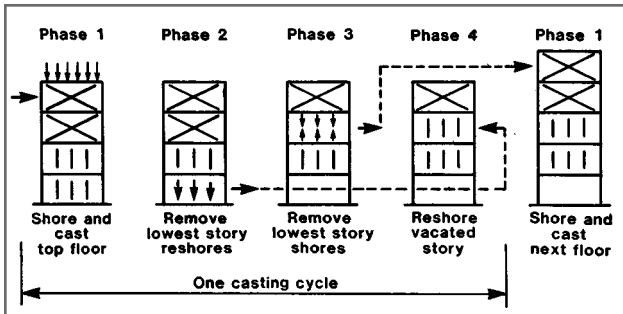


Fig. 1 - Example of a Casting Cycle

ACI's *Guide to Formwork for Concrete* (4) discusses the two most common shore replacement methods: backshoring and reshoring. Backshoring allows early age stripping since only small slab areas are unsupported during the removal and re-

placement process. Backshoring requires a large amount of reshore material. Reshoring allows expeditious removal of shores and uses less material than backshoring since fewer levels need to be reshored. In the reshoring method, all the shores under the most recently cast floor are removed so that the load in the slabs below reduces to only their self weight plus the weight of the reshores. The most recently cast slab will also only be subjected to its self weight. Reshores are then installed and formwork for the next floor is built. When the next slab is cast, its weight, plus that of the formwork and the concreting operation live load will be shared by the shored in-place slabs. In this approach it is imperative that the reshores are installed in such a manner that they are not preloaded. It is also imperative in this approach to consider the strength development of the most recently cast slab at the point in time when form stripping and reshoring is desired.

If a two or three-day cycle is desired, a system of preshores, primary forms, and shores is used. The system allows fast cycling of some of the forms while maintaining adequate support of the newly cast slabs. A critical consideration in a two or three-day cycle operation involves stripping of the forms for the most recently cast slab. This slab, being about 28-hours old, is already supporting the next floor's form load. It is imperative that all the shores under this slab not be slackened in one operation. Preshores are placed so that, during the stripping process, the 28-hour old slab will never have an unsupported span of more than 8 feet. In this method forms above the preshores remain

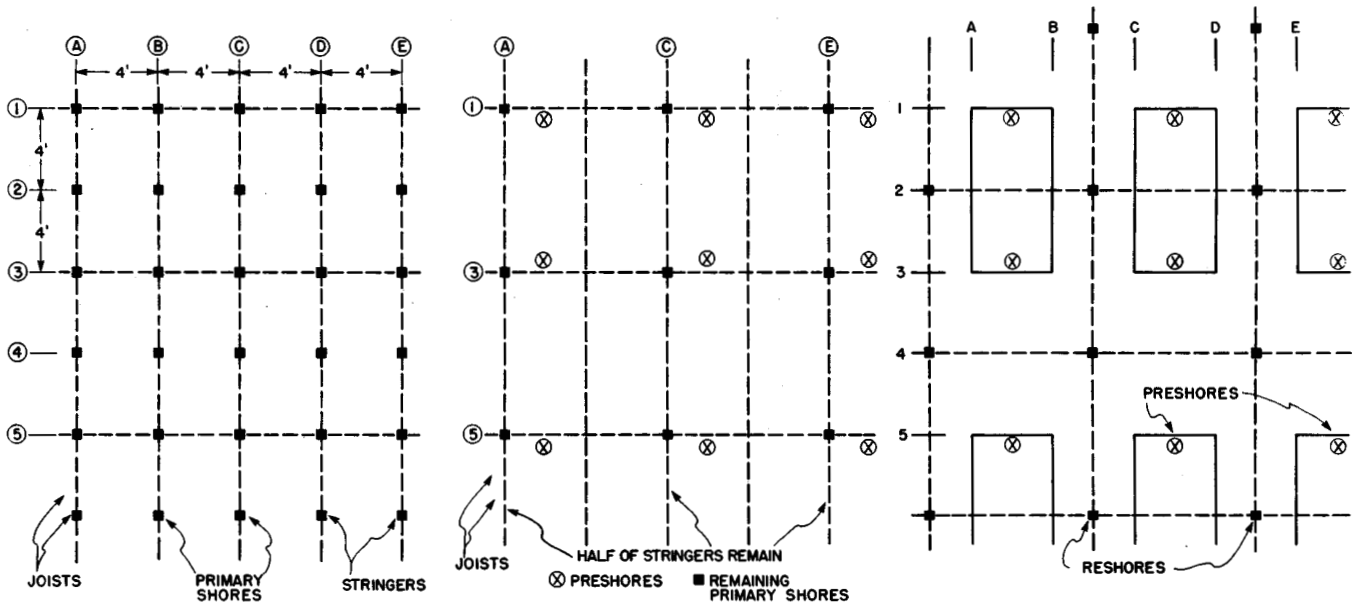


Figure 2a. Plan view of original formwork with primary shores in place on 4x4-foot grid. Dashed lines show 4x8-foot plywood sheets used for deck forming.

Figure 2b. Preshores placed under alternate sheets of plywood (Step 1) are about 8 feet apart. Thinning out (Step 2) has removed half of the stringers and three-fourths of the primary shores. Most of the joists are still in place.

Figure 2c. The rest of the formwork has been removed (Step 3) except for plywood pinned by preshores. Reshores are placed on an 8-foot grid. Not shown in this schematic are the reshores which are placed within 3 feet of column faces on all four sides.

\*After a complete bay has been reshored, its preshores and pinned plywood are removed in the following manner. A reshore is placed next to a preshore. The preshore is removed and used as the reshore at the next preshore location. This procedure repeats until all preshores have been replaced by reshores. In the process, all pinned plywood has been removed.

Fig. 2 - Preshoring Methodology

temporarily pinned. Two or three-day cycle systems that use dimension lumber framing usually require two or sometimes 2 1/4 sets of forms and about 8 to 10 levels of reshoring. (5) Figures 2a, 2b & 2c illustrate this method.

Two or three-day cycles can also be achieved in flying truss systems. In some cases the truss-supported panels are limited to an eight foot width and are set two foot clear side by side. The two foot clearance allows room for lines of permanent shores. Panels are alternately lowered and decks reshored, thereby not exceeding the eight foot clear span limit. (See Figures 3a & 3b).

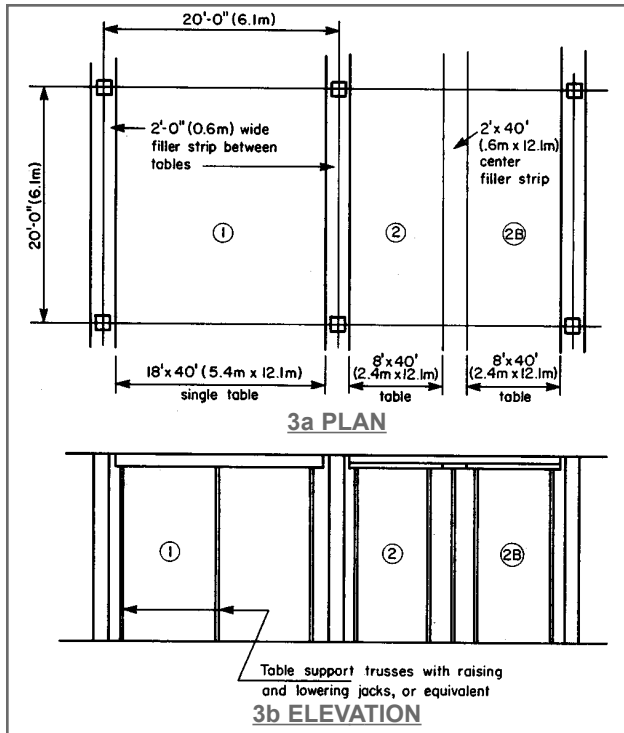


Fig. 3 - Flying Truss Rapid Cycling

## STRENGTH OF IN-PLACE CONSTRUCTION

In order to evaluate the structural affects of the forming system being employed, two determinations need to be made:

1. What portion of the temporary loads goes to each of the floors interconnected by the formwork system?
2. What is the capacity of each of the interconnected floors?

Four conditions influence the distribution of the temporary loads:

1. Effect of cure time on  $f'_c$  and EC.
2. Relative stiffness of the interconnected floors.
3. The number of floors that are interconnected.
4. The particular method of reshoring, preshoring, or backshoring being employed.

It is generally accepted that assumptions based on principles of engineering mechanics can be used to determine load distribution. These assumptions are:

1. Flexural stress is relative to deformation. That is, a slab not allowed to deflect will not carry any load.
2. Stiffness is related to concrete strength development as well as cross section. Inter-connected floors will share the load in proportion to their relative stiffness.
3. In comparison to the floors, the shores, reshores, or backshores are infinitely rigid. These vertical elements do not deform and only serve to interconnect the in-place floors.

The following hypotheses stem from these assumptions:

1. Floors interconnected by shores, reshores, or backshores will deflect equally under application of the temporary construction loads.
2. Interconnected floors will share the construction load in proportion to their relative flexural stiffness.
3. Assuming a compacted subgrade or a slab on grade to be an unyielding support, floors shored or backshored to grade will not carry any of the construction load.

Conditions that influence the capacity of the in-place concrete decks are:

1. Total factored load and design LL/DL ratio
2. Strength development
3. Critical mode of deck behavior (flexure, bond, or shear)

The Strength Design Method is commonly used to proportion concrete decks. In this method, load factors of 1.4 and 1.7 are used, respectively, for the dead and live service loads. ANSI A 10.9 (6) cites a construction load factor of 1.3; designers may choose to use a value of 1.4. A difference exists in the magnitude of load to be used in accounting for concrete placing operations: the Scaffold and Shoring Institute recommends a value of 20 psf while ACI Committee 347 suggests a value of 50 psf. Use of a deck live load reduction by the Engineer of Record, while a long term benefit, usually lessens the capacity of the decks in sharing the temporary concreting construction loads.

## PROPERTIES OF CONCRETE AT EARLY AGES

With regard to early age concrete structural properties, ACI SP-27 (7) includes the following expressions for  $E_c$  and  $f'_c$  with "t" subscripts denoting less than 28-day values:

$$E_t = 33 W^{1.5} f'_c t^{0.5} \text{ and } (f'_c)_t = \frac{t}{4 + 0.85t} f'_{c-28}$$

Another source of early age concrete structural properties is ACI SP-95 (8). Furthermore, early age concrete properties can be determined experi-

mentally by the testing of laboratory-cured cylinders done in conjunction with correlation of the non-destructive test method planned for a particular building project.

It is generally accepted that, in under-reinforced cross-sections, flexural strength is for the most part independent of the cylinder strength. See Fig. 4. There is a divergence within the literature regarding how early age concrete tensile strength should be related to the cylinder strength. While the ACI 318 Building Code (9) relates shear and bond to the square root of the cylinder strength, others suggest cylinder strength powers of 0.71 and 0.8 (10).

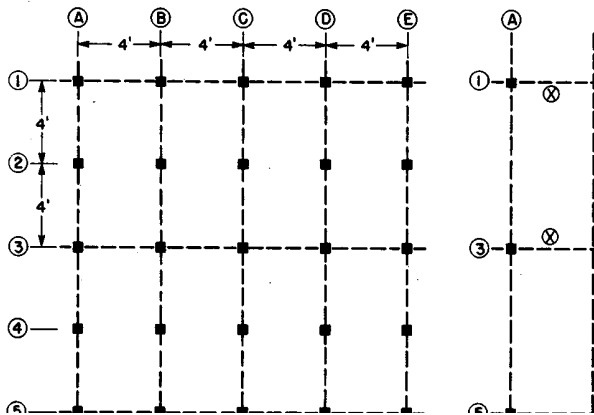


Fig. 4 – Variation of Concrete Member Strength With Age.

After determination of the variables of load, load factor, and concrete strength, the Engineer of Record can proceed to judge the adequacy of the in-place construction. The loads on the in-place construction will result from the analysis of the proposed forming system. This analysis will have recognized the number of levels of forms and shores, the shore replacement method employed, and the casting cycle. A common assumption regarding load characteristics is that shores are spaced close enough such that the deck loading can be considered to be uniformly distributed.

## SERVICEABILITY CONSIDERATIONS

Sbarounis, writing in *Concrete international* (11), presents a simplified method of predicting long term deflections caused by construction loads in multistory concrete flat plate buildings. In this method, the maximum construction dead load is taken to be  $W_n - 2(W_{se} + 10)$ , where  $W_{se}$  is the self weight of a slab and 10 psf is the formwork load. The maximum construction live load is taken to be  $W_l = 50/N$  where N is the number of interconnected floors. With these values, two components of the total deflection can be developed.

1.  $D'_{max}$ , the immediate deflection due to  $W_n + W_l$ .

2.  $D_{sd}$ , the immediate secant service dead load deflection considering the concrete age at the time of maximum construction load application.

Sbarounis cites the following multipliers to be applied to the immediate secant service dead load deflection:

1. Permanent set and creep: 1.5
  2. Creep after one month : 1.3
  3. Shrinkage : 1.2
  4. Immediate : 1.0
- Total : 5.0

Gardner and Fu, writing in *The Journal of the American Concrete Institute*, (12) present a design method that includes a construction load dependent creep term to use when predicting the long term deflection of a slab structure. They also report results of an experimental investigation where the measured long term deflections were five to eight times the sustained load deflections computed with the 28-day concrete properties. The report also includes comparisons of long term deflection ratios calculated by other authors. The authors present the following long term deflection equation:

$$\delta_{total} = \delta_{sh} \delta_{sus} [1 + C_t (1 + CL/UL)]$$

Where:

$\delta_{sh}$  = Shrinkage component of deflection

CL = Maximum construction load in multiples of slab dead load

UL =  $1.4D + 1.7L$

$\delta_{sus}$  = Service load deflection

$C_t$  = Creep coefficient

## INTERACTION BETWEEN THE FORMWORK CONTRACTOR AND THE ENGINEER OF RECORD

The vehicle for passage of information and requirements between the two parties principal to the superstructure construction is the project Contract Documents. The Project Drawings and Specifications are used to present such items as design service loads, minimum concrete cure times, formwork drawing requirements, and other required reviews and/or approvals. In addition to a detailed presentation of formwork drawing and calculation suggestions, Reference 4 discusses the division of responsibility between the Formwork Contractor and the Engineer of Record. Sections of Reference 4 that cover these topics are reprinted in Appendix A.

## TERMINOLOGY

For those involved with the construction of multistory cast-in-place concrete buildings, the terms backshoring and reshoring are commonplace; unfortunately, their meanings are sometimes interchanged. Reference 4 shows the similarities and differences between these terms. Appendix B is a reprint of this work which appears in Sections 1.2 and 3.8. Table 3.8.1 on the next page summarizes that comparison.

**TABLE 3.8.1 – Comparison of Backshoring and Reshoring**

<b>BACKSHORING</b>	<b>RESHORING</b>
Strip small areas.	Strip several entire bays.
Do not let slab deflect.	Allow slab to deflect.
Install backshores before any further stripping occurs.	Install reshores without removing deflection.
Slab does not carry its own weight.	Slabs carry their own weight.
Backshores have an initial load.	Reshores have no initial load.

The development of rapid cycle (2-3 days per floor) construction has created another term: pre-shoring. Cantor & Rizzi (13) and Grossman (5) used this term in reports of their rapid cycle work involvement. Preshoring is a three-step shore removal process, the intent of which is to control unsupported slab spans. In this process, specified shores are removed while others are left in place, reshores are installed at the locations of the removed shores and, in the last step, the remaining shores are removed and replaced with reshores. Preshoring can be viewed as a kind of patterned and scheduled backshoring.

### **SUMMARY**

Attainment of fast-cycle cast-in-place concrete construction requires interaction between the Formwork Contractor and Engineer of Record together with sophisticated coordination of the building superstructure trades. Five to seven days "typical floor" construction cycling is easily achievable and two to three days cycling is not uncommon in some areas. The formwork systems most often employed in rapid cycle work are conventional and ganged systems or flying truss systems. The different shore

replacement methods available (backshoring, reshoring, and preshoring) each have unique characteristics that must be recognized.

Principles of engineering mechanics are applied to assess the effects of the forming operations on the strength and serviceability of the in-place construction. The key element of a reshoring analysis is the apportioning of the construction loads throughout the system of slabs interconnected by shores and reshores. How these loads will be distributed is for the most part dictated by the particular shore replacement method to be employed. Assessment of the in-place concrete strength development is critical. Attention must be given to the terminology employed in describing the different shore replacement procedures.

The division of responsibility for the formwork and the in-place construction needs to be defined in the project Contract Documents.

### **IMPLIED PREFERENCE OF RESHORING METHOD**

The Engineer of Record will sometimes specify a particular shore replacement method to be used in the construction of a cast-in-place concrete building. The formwork industry recommends performance-oriented specifications. When given a choice, (by virtue of a performance-oriented specification) Formwork Contractors will usually favor one of the three basic shore replacement methods: backshoring, reshoring, or preshoring.

This paper has been prepared by individuals with differing personal preferences as to shore replacement method. However, since this paper is intended for industry-wide use, objectivity of presentation was attempted. The reader should presume neither preference nor disfavor in the discussion of the various reshoring methods included in this report.

## **APPENDIX A**

Excerpted with permission from *Guide to Formwork for Concrete* (ACI 347R-88)

**1.4.4 Design, inspection, review, and approval of formwork** — Although the safety of formwork is the responsibility of the contractor, the engineer, architect, or approving agency may under certain circumstances wish to review and/or approve the formwork, including drawings and calculations. If so, the engineer/architect should call for such review or approval in the contract documents.

Approval might be required for unusually complicated structures, for structures whose designs were based on a particular method of construction, for structures in which the forms impart a desired architectural finish, for certain post-tensioned structures, for folded plates, for thin shells, or for long-span roof structures. The following items should be clarified in the contract documents:

- a. By whom formwork will be designed
- b. By whom, when, and for what features formwork will be inspected
- c. What reviews and/or approvals will be required:
  1. for formwork drawings
  2. for the forms before concreting and during concreting
  3. who will give such reviews and/or approvals

**2.1.3 Basic objectives** — Formwork should be designed so that concrete slabs, walls, and other members will be of correct dimensions, shape, alignment, elevation, and position and within established tolerances. Formwork should also be designed so that it will safely support all vertical and lateral loads that might be applied until such loads can be supported by the concrete structure. Vertical and lateral loads must be carried to the ground by the formwork system or by the in-place construction that has adequate strength for that purpose. Responsibility for the design of the formwork rests with the contractor or the engineer hired by the contractor to design and be responsible for the formwork.

**2.1.5 Formwork drawings and calculations** — Before constructing forms, the contractor, if required, will submit detailed drawings and/or design calculations of proposed formwork for review and/or approval by the engineer/architect or approving agency. If such drawings are not in conformity with contract documents as determined by the engineer/architect or approving agency, the contractor will make such changes as may be required prior to start of construction of the formwork.

## APPENDIX A (CONT'D)

The review approval of the formwork drawings in no way relieves the contractor of the responsibility for adequately constructing and maintaining the forms so that they will function properly. If reviewed by persons other than those employed by the contractor, the review or approval indicates no exception is taken by the reviewer to: the assumed design loadings in combination with design stresses shown; proposed construction methods; placement rates, equipment, and sequences; the proposed form materials; and the overall scheme of formwork.

All major design values and loading conditions should be shown on formwork drawings. These include assumed values of live load; the compressive strength of concrete for formwork removal and for application of construction loads; rate of placement, temperature, height and drop of concrete; weight of moving equipment which may be operated on formwork; foundation pressure; design stresses; camber diagrams; and other pertinent information, if applicable.

In addition to specifying types of materials, sizes, lengths, and connection details, formwork drawings should provide for applicable details such as:

a. Procedures, sequence, and criteria for removal of forms, shores, and reshores.

b. Design allowance for construction loads on new slabs should be shown when such allowance will affect the development of shoring and/or reshoring schemes (see Sections 2.5.3 and 3.8 for shoring and reshoring of multistory structures).

**2.5.3 Multistory structures** — Prior to construction, an overall plan for scheduling of shoring and reshoring or backshoring, and calculation of loads transferred to the structure, should be prepared by a qualified and experienced formwork designer. The structure's capacity to carry these loads should be reviewed or approved by the engineer architect. The plan and responsibility for its execution remain with the contractor.

Shores and reshores or backshores (as defined in Section 3.8) must be designed to carry all loads transmitted to them. A rational analysis should be used to determine the number of floors to be shored, reshored, or backshored and to determine the loads transmitted to the floors, shores, and reshores or backshores as a result of the construction sequence.

The analysis should consider, but should not necessarily be limited to, the following:

1. Structural design load of the slab or member including live load, partition loads, and other loads for which the engineer designed the slab. Where the engineer included a reduced live load for the design of certain members and allowances for construction loads, such values should be shown on the structural drawings and be taken into consideration when performing this analysis.

2. Dead load weight of the concrete and formwork.

3. Construction live loads, such as placing crews and equipment or stored materials.

4. Design strength of concrete specified.

5. Cycle time between placement of successive floors.

6. Strength of concrete at time it is required to support shoring loads from above.

7. The distribution of loads between floors, shores, and reshores or backshores at the time of placing concrete, stripping formwork, and removal of reshoring or backshoring<sup>2.6.2.7</sup>

8. Span of slab or structural member between permanent supports.

9. Type of formwork systems, i.e., span of horizontal formwork components, individual shore loads, etc.

10. Minimum age where appropriate.

Commercially available test cells can be placed under selected shores to monitor actual shore loads to guide the shoring and reshoring process as construction proceeds.<sup>2.8</sup>

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## APPENDIX B

Excerpted with permission from *Guide to Formwork for Concrete* (ACI 347R-88).

### 1.2-Definitions

The following definitions will be used in this guide. Many of the terms may also be found in ACI 116R.

**Backshores** — Shores placed snugly under a stripped concrete slab or structural member after the original formwork and shores have been removed from a small area without allowing the slab or member to deflect or support its own weight or existing construction loads from above.

**Centering** — Specialized temporary support used in the construction of arches, shells, and space structures where the entire temporary support is lowered (struck or decentered) as a unit to avoid introduction of injurious stresses in any part of the structure.

**Diagonal bracing** — Supplementary formwork members designed to resist lateral loads.

**Engineer/architect** — The architect, engineer, the architectural firm, the engineering firm, or other agency issuing project drawings and specifications and/or administering the work under project specifications and drawings.

**Flying forms** — Large mechanically handled sections of formwork; frequently include supporting truss, beam, or scaffolding units completely unitized. Term usually applies to floor forming systems.

**Form** — A temporary structure or mold for the support of concrete while it is setting and gaining sufficient strength to be self-supporting.

**Formwork** — Total system of support for freshly placed concrete including the mold or sheathing that contacts the concrete as well as all supporting members, hardware, and necessary bracing.

## APPENDIX B (CONT'D)

**Ganged forms** — Prefabricated panels joined to make a larger unit for convenience in erecting, stripping, and reusing.

**Horizontal lacing** — Horizontal members attached to shores to reduce their unsupported length, thereby increasing load capacity.

**Multi-tier shoring** — Single post shores used in two or more tiers to increase the height of the shoring system.

**Reshores** — Shores placed snugly under a stripped concrete slab or other structural member after the original forms and shores have been removed from a large area, thus requiring the new slab or structural member to deflect and support its own weight and existing construction loads applied prior to the installation of the reshores.

**Shores** — Vertical or inclined support members designed to carry the weight of the formwork, concrete, and construction loads above.

### 3.8 — Shoring and reshoring of multistory structures

**3.8.1 Discussion** — Multistory work represents special conditions, particularly in relation to removal of forms and shores. Reuse of form material and shores is an obvious economy. Furthermore, the speed of construction customary in this type of work provides the additional advantage of permitting other trades to follow concreting operations from floor to floor as closely as possible. However, the shoring which supports green concrete is necessarily supported by lower floors which may not be designed for these loads. For this reason shoring must be provided for a sufficient number of floors to develop the necessary capacity to support the imposed loads without excessive stress or deflection.

**Reshoring and backshoring** are procedures used to distribute construction loads through the lower floors. Though load distribution analysis is similar for the two, there are significant differences in magnitude, duration, and timing of floor and shore loads for the two procedures.

For purposes of this discussion the following definitions apply:

**Shores** — Vertical or inclined support members designed to carry the weight of formwork, concrete, and construction loads above.

**Reshores** — Shores placed snugly under a stripped concrete slab or structural member after the original forms and shores have been removed from a large area, thus requiring the new slab or structural member to deflect and support its own weight and existing construction loads applied prior to the installation of the reshores. It is assumed that the reshores carry no load at the time of installation. Afterward, additional construction loads will be distributed among all members connected by reshores.

**Backshores** — Shores placed snugly under a stripped concrete slab or structural member after the original formwork and shores have been removed from a small area without allowing the slab to deflect or support its own weight or existing construction loads from above. It is assumed that the backshores carry the same load as that carried by the original shores they replace. Original shores left in place with or without removal of the forms act in the same way as backshores. Added construction loads will be distributed among all members interconnected by backshores after the first level support at grade is removed.

Table 3.8.1 compares key features of reshoring and backshoring. With *backshoring*, so long as the first level shores remain in place in contact with grade, each tier of shores must carry the weight of all concrete and construction loads above it. This may be the weight of several floors. While *reshoring* remains in place at grade level, accumulated shore loads are less because each slab has been permitted to carry its own weight before reshores were put in place.

Once the tier of backshores or reshores in contact with grade has been removed, the assumption is made that the system of slabs behaves elastically. The slabs interconnected by reshores or backshores will deflect equally during addition or removal of loads. Loads will be distributed among the slabs in proportion to their developed stiffness. Addition or removal of loads may be due to construction activity or to removing shores, reshores, or backshores in the system.

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## SOURCES FOR REPORT FIGURES

Fig. #1 — Gross, J.L., and Lew, H.S., "Analysis of Shoring Loads and Slab Capacity for Multistory Concrete Construction"; *SP-90*: American Concrete Institute, Detroit, MI, 1986.

Fig. #2 — Grossman, J.S., "Two-day Construction Cycle for High-Rise Structures Based on Use of Preshores"; *Concrete Construction*, Concrete Construction Publications, Addison, IL, March, 1986.

Fig. #3 — Cantor, I.G., and Rizzi, A.V., "Reshore and Preshore Procedures for Flat Plate Slabs", *Forming Economical Concrete Buildings: Proceedings of An International Conference*, Portland Cement Association, Lincolnshire, IL, November, 1982.

Fig. #4 — Gardner, N.J., and Agarwal, R.K., "Form and Shore Requirements for Multistory Flat Slab Type Buildings"; *ACI Journal*; ACI, November, 1974.

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11. Sbarounis, J.A., "Multistory Flat Plate Buildings - Effect of Construction Loads on Long Term Deflections", *Concrete International*; ACI, Detroit, MI, April, 1984.
12. Gardner, N.J., and Fu, H.C" "Effects of High Construction Loads on the Long Term Deflections of Flat Slabs", *ACI Structural Journal*, ACI, Detroit, MI, July-August, 1987.
13. Cantor, I.G" and Rizzi, A.V., "Reshore & Preshore Procedures for Flat Plate Slabs", *Forming Economical Concrete Building: Proceeding of An International Conference*, PCA, Lincolnshire, IL, November 1982.

Note. This report was prepared by the CRSI Committee on Concrete Forming

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