DATUM

Slipformed Core Construction

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SLIPFORMED CORE CONSTRUCTION

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Dallas/Austin

DATUM

PREFACE

This manual was written as a guide for Datum's engineers to use on future projects. It is an effort to assure that the benefits of our past experience with slipform is incorporated into our future projects. Each engineer starting a new slipform project is requested to read this manual and discuss his findings with the team members that were associated with the previous slipform core projects designed by Datum's Engineers.

I also want to thank Doug Pruitt of Sundt Corporation for the illustrations he provided, for the previous articles he has written on slipforming, and for the superior work Sundt Corporation did on Williams Square, Olympia and York Tower in Dallas, Texas, and the Atlantic Center project in Atlanta, Georgia.

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INDEX

INTRODUCTION

Although slipform concrete construction was used somewhere around the first of the century (1904 - 1905) in Kansas City for a rectangular grain tank that was approximately 25 to 30 feet high, slipform core construction for building construction did not start until the mid 1950's. To the best of our knowledge, the first indication of a slipform core for building construction was the Buffalo Bank Building constructed in the mid 1950's. The slipping operation was done by Heede International, utilizing hydraulic jacks.

The original slipform construction was primarily used for the construction of grain silos and then evolved into the construction of missile silos. The slipping operation on the silos typically continued around the clock until the slipping operation was complete.

The erection of these silos was considerably simpler to construct than a concrete core for a building due to the absence of blockouts for doors, mechanical units, embeds for steel floor beams, conduit, etc.

The slipping process has evolved from small hand screwed jacks with threaded rods (in which everyone turned one-quarter of a turn at the sound of the foreman's whistle) to pneumatic jacks developed sometime in the 1930's and then hydraulic jacks developed in the early 1940's.

Datum's first project, using slipform core construction, was in 1969. Although we were not pioneers in either the process of slipforming or the utilization of slipforming for concrete building cores, we have participated in refining the process from the typical mid-rise concrete cores to the construction of the Atlantic Center core, which was 725'-6" tall and was the tallest slipform concrete core in the United States at the time of its construction.

We have had many experiences (some good and some bad) with slipform core construction. The purpose of this manual is an attempt to document our experiences for our staff's future reference when constructing slipform concrete cores. We hope that it will not only be useful for this purpose but will also serve as a valuable reference tool for our colleagues.

A BRIEF OUTLINE OF DATUM'S SLIPFORM CONSTRUCTION EXPERIENCE

Datum has been the structural designer on numerous mid-rise and high rise slipform concrete core projects, starting in 1969 with the Parkway Central office building in Arlington, Texas. Our most recent slipform core project was the Atlantic Center/IBM Tower in Atlanta, Georgia, completed in 1990, which at the time was the tallest slipform core project in the United States. Over the past 21 years we have had the opportunity to accumulate a vast amount of experience and information regarding slipform concrete core design on a number of highly successful projects. We would like to share our experiences with you.

The following is a list of some of our more notable slipform concrete core projects:

> **Atlantic Center/IBM Tower**, Atlanta, Georgia - 50 story, 1,100,000 square foot office building with slipform core and steel frame. The building is 800 feet tall and the core is 725'-6" tall. This project was designed by the Datum-Moore Partnership under the guidance of Thomas Taylor **(See Figures 1, 2, and 3).**
>
> **The Towers at Williams Square**, Las Colinas, Irving, Texas - A 27 story building with 1,000,000 square feet, steel frame braced by the concrete core. This project was designed by the Datum-Moore Partnership.
>
> **Olympia & York Office Tower**, Dallas, Texas - 38 story office building, 1,000,000 square feet, slipform core with structural steel floor **(See Figures 4, 5, and 6).**
>
> **Interfirst Bank (Citizens Bank)**, Dallas, Texas - 13 story, 120,000 square feet, slipform core with structural steel floor and precast concrete perimeter **(See Figures 7 and 8).**
>
> **Park Central Tower**, Dallas, Texas - 22 story, 700,000 square feet, slipform core with structural steel floor. Datum was the conceptual design engineer on this project.
>
> **Parkway Central Tower**, Arlington, Texas - 14 story, 300,000 square foot office building with a slipform concrete core and structural steel floor.
>
> **Southland Corporation Corporate Headquarters**, Dallas, Texas - 11 story, slipform core with structural steel floor and precast concrete exterior.
>
> **Central Research Library**, Dallas, Texas - 12 story, structural steel frame with slipformed stair shafts and central core.

Slipform construction was selected on these buildings for reasons that were specific to each project. However, all shared in the common economic advantages that will be outlined in the next chapter.

Figure 1
Atlantic Center/IBM Tower
Atlanta, Georgia

Figure 2
Atlantic Center/IBM Tower
Atlanta, Georgia

Figure 3
Atlantic Center/IBM Tower
Atlanta, Georgia

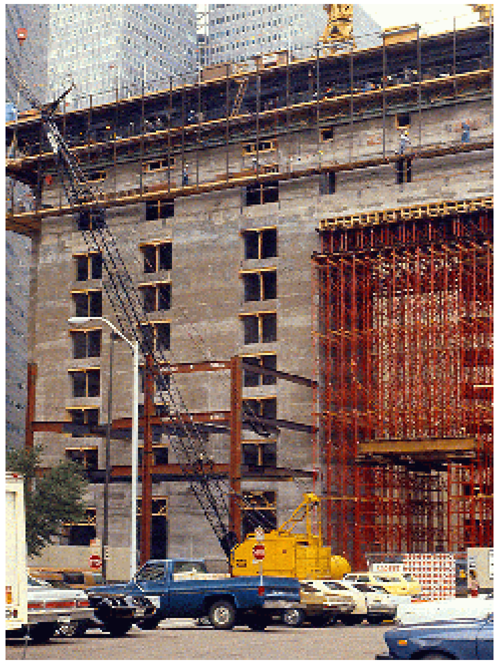

Figure 4
Olympia & York Tower
Dallas, Texas

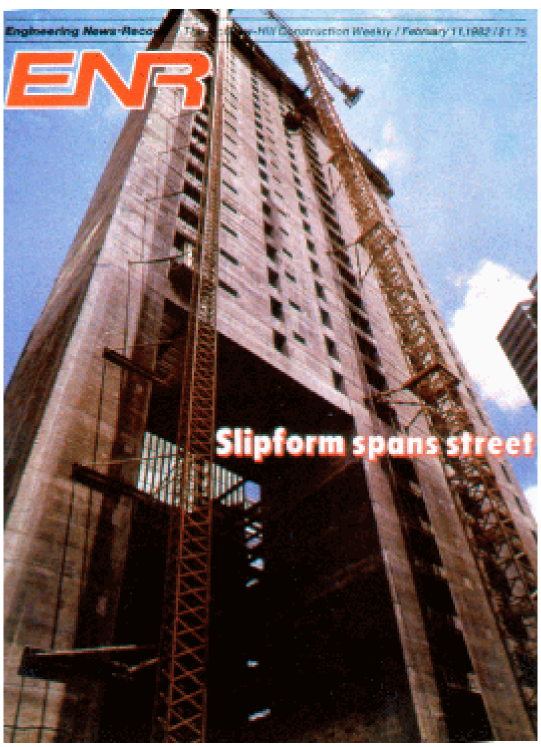

Figure 5
Olympia & York Tower
Dallas, Texas

Figure 6
Olympia & York Tower
Dallas, Texas

Figure 7
InterFirst Bank Building
Richardson, Texas

Figure 8
InterFirst Bank Building
Richardson, Texas

ECONOMICS OF SLIPFORM CONSTRUCTION

The primary economic advantage of a slipformed concrete core in a building is arrived at by organizing the concrete walls in the core to correlate with fixed walls that are otherwise required by function. This arrangement allows the walls to perform "double-duty." The walls become the structural wind bracing element of the building, also providing gravity load-carrying capacity, while at the same time providing the fire separation around stair and elevator shafts required by the Building Code.

These slipform concrete walls are located where fixed walls (those which will not be relocated over the life of the building) occur, such as walls around lavatories, mechanical rooms, electrical rooms, telephone closets, and vertical chases for mechanical and electrical systems. Therefore, when cost estimating various structural framing options, one must include the added value of these walls as architectural separation walls when compared to framing systems that do not create fixed walls or provide fireproofing.

A major savings when using slipform construction comes from the low cost of forms per square foot of contact area. Typically, slipforms are only four feet high and are commonly used up to heights of 400 feet (on the Atlantic Center project the same form was utilized up to 725 feet). This gives a form reuse factor of 100, with no stripping or resetting required. Furthermore, working decks and finishing scaffolds are part of the form assembly eliminating the scaffolding that would otherwise be required.

The reduced construction time produces an additional savings of in-place construction cost. On the 50 story Atlantic Center project over ten weeks of total construction time was eliminated by the use of slipformed concrete core construction, resulting in faster occupancy and reduced interim interest cost.

Another economy, which turns out to be fairly significant, is in the simplicity of fabrication and erection of structural steel floors and columns when associated with the stabilizing slipform concrete core. This became immediately apparent to us on our original 1969 Parkway Central project, when a smaller more competitive structural steel fabricator, who would have been unable to fabricate the more complex structural steel normally associated with high rise office buildings, turned in the lowest bid. Since the core resists all of the wind forces (which transfer from the exterior wall through the floor diaphragm to the core), the structural steel can be designed as simple beams and braced columns with simple bolted connections, thus eliminating moment connections between beams and columns, which reduces the cost of steel fabrication below the standard anticipated cost. Similar economies occur for the erector as well, since the steel frame can be quickly stabilized by simply welding it to the steel anchor plates cast in the core.

We have continued to experience highly competitive pricing for structural steel on all of our slipform projects. Due to the wind bracing and gravity load capacity furnished by the core, the amount of structural steel per square foot is reduced to below that required to support gravity loads only. In summary, low tonnage, simplicity of fabrication and erection contribute to substantial savings in structural steel framing costs.

Other economies associated with slipform core construction include the rapid installation of elevators and stairs and their early use for construction purposes. The mechanical contractor can install all of the vertical plumbing risers from the finishing scaffold and the slipform contractor can install all of the structural steel inside the core, including elevator divider beams, during the slipping operation.

Almost every slipformed concrete structure can realize a majority of these economies. Whether or not the benefits of slipform construction are applicable on a given project, slipform construction should be taken into consideration during the initial value engineering process.

THREE METHODS OF SLIPFORM CONSTRUCTION

There are three basic methods of constructing a building with a slipformed concrete core:

> One, which is the method we recommend, is to construct the core completely independent of the floor construction, with the core topping out either before the structural steel erection begins or shortly thereafter.
>
> Another method is to erect the core on a floor-a-day basis for five to ten days, then pause and build the floor up to the same level as the core, continuing this process incrementally throughout the project.
>
> A third method is to carry on slipforming and floor construction operations simultaneously, on a daily one-floor-at-a-time basis. This method should only be used if the core is not entirely stable within itself and needs the additional horizontal support of the floor system.

On all of our projects we have used the first method of slipforming. The core is always designed to be capable of extending all the way from the foundation to the top without bracing from the adjacent floor members. The core is designed to have the strength and stability to act as an independent element which can resist all of the wind and construction loadings that are imposed on it during construction. The engineer must pay special attention to the stability of the core cross-section and utilize the appropriate interior cross-walls as bracing walls. Additional bracing walls, that may be required, are generally minor and are offset by the fact that they can be located where architectural functional walls are stipulated. Horizontal diaphragms can also be cast periodically inside the core to strengthen the core during construction. If effective diaphragms in the core are not attainable, due to elevator openings, vertical shafts, etc., then diagonal guy wires can be employed within the core to provide diaphragm strength.

Our experience has shown the first method to have more benefits than the second or third. The slipforming subcontractor's specialized crews are able to work continuously without delays. Whereas the other methods require waiting for floor construction to catch up, which generally takes three to five times longer than the slipforming operation itself.