California State Printing Office (Archives Building) HABS No. CA-2301
1020 O Street
Sacramento
Sacramento County
California

HABS
CAL,
34-SAC,
59-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Buildings Survey
National Park Service
Western Region
Department of Interior
San Francisco, California 94102

HABS
CAL,
34-SAC,
59-

HISTORIC AMERICAN BUILDING SURVEY
CALIFORNIA STATE PRINTING OFFICE (Archives Building) HABS No. CA-2301

Location: 1020 O Street
Northwestern corner of the block surrounded by 10th, 11th, O and P Streets in the City of Sacramento
Sacramento County

Present Owner: State of California

Present Occupants: Secretary of State

Present Use: State Archives

Significance: The original 1922 building has distinctive characteristics in its column-and-drop slab framing system indicative of significant reinforced concrete technology for the 1921-32 period. The exterior design actively contributes to the architectural rendering of the engineering system. Its 30-year existence as the State Printing Office was followed by an equal period as the State Archives. It contributes historically to the government district surrounding the Capitol.

Historian: Karen Weitze
Architectural Historian
3311 Oakmont Blvd.
Austin, Texas 78703
August 1989

Prepared for the State of California
Department of General Services
Office of Project Development and Management
400 R Street, Suite 5100
Sacramento, CA 95814

PART I. PHYSICAL CONTEXT OF THE STATE PRINTING PLANT

The original two-story structure of the State Printing Plant dates to 1922 and is on the northeastern corner of the downtown Sacramento city block surrounded by 10th, 11th, O and P Streets. In 1931 a two-story addition to the west was built, and was expanded to a three-story addition in 1932. Prior to the construction of the 1931-32 additions, a one-story warehouse running the depth of the original structure and a row of one-story garages also running the depth of the structure occupied the western edge of the 1922 building. These earlier structures appear to have been built in conjunction with the original structure.

The State Printing Plant building has its major entrance on the north side of the block, facing O Street. Its secondary public facade faces 11th Street. The rear facade, facing an alley, and the western facing facade (toward 10th Street) are non-public facades.

Street configuration prior to construction of the building (from 1915) showed the streets surrounding the block on which the Printing Plant was located as 80 feet wide with a 20-foot alley running through the block at mid-point from east to west. The original State Printing Plant was contained in roughly the northeastern quadrant of the block bounded by the alley and 11th and O Streets (Sanborn Insurance Company, "Sacramento" Map, 1915). The building had loading docks at its rear facade. The 1931-32 addition to the State Printing Plant extended the structure into the block to the west.

Today the adjacent streets have somewhat specialized functions. Tenth Street is a major artery into the core of the State Capital, placing what was the non-public facade of the State Printing Plant building in an accented public viewshed. Eleventh Street is less heavily used by concentrated vehicular traffic, but is actively used by a mix of pedestrians and autos in conjunction with State business. The original secondary facade of the building continues to work as originally intended. O Street in front of the building's major public facade has been developed as a light rail corridor, with secondary pedestrian use and minor vehicular traffic.

The State Printing Plant building, now housing the State Archives, is part of the State Capitol core area of Sacramento. The core area contains the State Capitol and numerous state office buildings housing agencies performing the functions of California's state government. The Capitol grounds, bounded by 10th, 15th, L and N Streets in the north-central part of this core area, consists of the Capitol itself and its surrounding park. The Capitol is one full block north of the State Printing Plant. A Classical Revival structure built between 1860 and 1874, the Capitol is on the National Register of Historic Places.

West of the State Capitol and two blocks distant from the State Printing Plant stand the Library and Courts Building and Office Building One, officially renamed the Jesse Unruh Building after a former California State Treasurer. These two buildings face one another across a park containing a fountain that is circled by Capitol Mall. (Although Capitol Mall west of this group is a broad four-lane avenue with a median parkway, it narrows at this point to a one-lane paved circle). Both buildings, similar to one another in design and expressing the Neo Classical style, were constructed between 1922 and 1928 and are listed on the National Register of Historic Places. They were the first State buildings built following legislation in 1911 authorizing State office construction.

PART II. HISTORICAL CONTEXT

A. GENERAL INTERPRETIVE BACKGROUND

The California Printing Office was created by legislative act in 1850 with the direction that all state documents be printed by this office. The agency was first housed in the Governor's Mansion in Capitol Park, at the east end of the State Capitol Complex until the mansion was destroyed by fire in 1923. (State Historic Resources Inventory for Capitol Park and Insectary.)

> The building was a project of the California Bureau of Architecture headed by George B. McDougall at the time of design. The State Printing Office was the third building undertaken in the downtown Capitol core as a part of office State building expansion. The first two buildings had been the Library and Courts Building (914 Capitol Mall) and Office Building 1 (915 Capitol Mall), in 1922-28.
>
> Plans for the State Printing Office were announced in Architect and Engineer of California in June 1922, with a projected cost of $240,000. Extant ink on linen drawings for the project, now held by the Office of the State Architect, are dated August 1922 and are signed by George B. McDougall. (Initials of the architect responsible for the actual drafting are D.A.N.) The linens show first story use as planned for composing, linotype machinery, printing presses, proof rooms, an office, casting rooms, a keyboard room, a shipping platform and trucking space. Second floor use was planned as a bindery, storage and and office. An article of 1927 in the Sacramento Bee describes the overall investment in the printing plant as $650,000, noting that the facility was the "largest and most completely equipped book printing shop west of Chicago." The article also noted that the building was "well-ventilated and excellently lighted". The Bee gave the date of occupation as September 1923 and described the building's use as: basement - stock room, carpenter shop, machine shop, and storage of supplies; first floor - composing room, open area for make-up work, 18 linotypes and monotypes, 10 presses (one

of which was a color press); second floor - bindery. The State Printing Office was responsible for all legislative reports, reports of heads of departments and all California school textbooks.

By July 1931 it had been announced in California Highways and Public Works that the Department of Finance was planning an addition to the printing plant at a projected cost of $81,000. By October the same departmental journal noted that the annex was under construction; and, the drawings for the addition are dated early October. For this addition the San Francisco firm of Martin A. Sheldon was hired. Subcontracting for ventilating, plumbing, heating and electrical work was let by December 1931 to local Sacramento firms.

By late January 1932, when the two-story addition must have been complete or nearly complete, a change of order was given to the firm of Martin A. Sheldon. Work continued on a third story unit until nearly the close of the year. The Bee noted that the $132,000 printing plant addition was dedicated in mid-November 1932. (This cost figure must have included both the 1931 two-story unit and the 1932 one-story unit added as a third floor.) On the drawings for the additions, also held by the Office of the State Architect, the basement was planned for paper storage; the first floor for a proof reading room, a printing press room, a paper curing room, and miscellaneous supply storage; the second floor was minimally planned for an accounting office, a book-keeper's office, a file room and a large open area; and the third floor was just noted as unspecified space. In the Sanborn insurance maps of the building from the early 1950s, the addition is dated 1932 and described as paper storage in the basement, printing on the first and second stories, and textbook warehouse on the third story.

In the mid-1950s the State Printing Plant moved to a new location outside the downtown core. By 1956 the Central Records Depository and State Archives had moved into the building. The Central Records Depository and the California State Archives had developed into more complex entities following the passage of legislation in 1927 and again in 1939 to regulate random State record destruction. In 1939 the State had approved the idea of fireproof facilities for archives' storage, and in 1947 the Secretary of State had been made custodian of the State public archives by law. The 1020 O Street location was the first (and to date only) major, independent location for the California State Archives and Central Records Depository. Subsequently, the name was changed to the State Archives Building, and at a later date Central Records moved to another location. (This section excerpted from Karen J.

Weitze, "Study of the Existing Buildings on the Department of General Services Site 7 Sacramento, CA," 1988.)

B. REINFORCED CONCRETE COLUMN-AND-FLAT SLAB FLOORING SYSTEM

The flooring system in the California State Printing Office is of an early, relatively experimental, reinforced concrete type. Designed by the California Bureau of Architecture (now the Office of the State Architect) under the direction of George B. McDougall, the 1922 structure falls within a three decade period of quick-paced, significant engineering innovations. From 1902 to 1932 engineers patented a series of experimental reinforced concrete flooring systems that fundamentally altered design and technology for multi-story structures carrying heavy dead and live loads - particularly loads resulting from either permanently placed or moveable machinery. Such flooring systems altered both engineers' and architects' pre-conceptions of how such structures could and would function, and of how they could and would appear in the 20th century, post World War I. The most basic change was from a beam-and-girder reinforced concrete flooring system - itself based on such systems originally designed and engineered for wood-frame, cast iron and steel structures - to a flat slab reinforced concrete flooring system. Early flat slab reinforced concrete flooring systems had several notable and easily recognized components, the most significant of which was the mushroom column. The two flat slab systems present in the California State Printing Office are evocative of commonly used technology and design, ca. 1916-1918, even though the actual date of construction for the building is 1922. Its technology and design are representative of state-of-the-art developments for about 1912-1914; by 1922 these particular flat slab systems were no longer at the avant-garde edge of technology and design, yet were certainly well within the range of systems being actively used across the United States and in Europe. Thus, the reinforced concrete slab systems incorporated in the California State Printing Office are representative of mid-stage developments from a highly significant period of reinforced concrete history, a period of technological and design history that was led by American engineers, but that was observed, complemented and carried forward by European architects and designers.

1. <u>The Flooring System in the California State Printing Office</u>

The flooring system in the 1922 State Printing Office employs two types of patented flat slab reinforcing: the four-way and two-way types. In conjunction with the four-way and two-way reinforcing systems for the first and second floor slabs, continuous drop panels, or slab-bands in several configurations, as well as single drop panels are used. Mushroom columns are integrally placed with the drop panels. Reinforced concrete beams and girders, in conjunction with concrete walls, are used sparingly as additional structural reinforcing in six areas:

1. the southwestern first floor rear corner loading platform;
2. the northwestern first floor stairwell and entrance hall;

3. the first and second floor elevator shafts and the rear stairs adjacent to the east wall of the loading platform;
4. the first floor skylight shaft adjacent to the north wall of the loading platform;
5. the second floor entrance hall and stairwell with its adjacent northwest corner offices; and
6. the second floor series of three skylight shafts at mid-point along the western wall.

The first floor of the California State Printing Office was designed for composing, linotype machinery, printing presses, proof rooms, an office, casting rooms, a keyboard room and a shipping platform with trucking space. That section of the first floor engineered to carry the heaviest dead and live loads, with emphasis on the dead loads, was the rear southeastern quadrant of the building. This section of the first floor (somewhat more than one-quarter of the overall first floor space) functioned as the press room, with 18 linotype and monotype machines, 10 printing presses (including a color press), and future plans for a magazine press. The composing, proof, casting, keyboard and office space appears to have been largely an open area consisting of bays between exposed mushroom columns, with several "rooms" actually set apart by hollow tile non-loadbearing walls. A loading platform with truck space in the rear southwestern quadrant of the building was engineered most conservatively to carry heavy vehicular live loads, employing reinforced concrete beam-and-girder construction with concrete loadbearing walls.[1]

The specified type of reinforced concrete slab system for the first floor was based upon projected use of the floor space, with the majority of the rear half of the State Printing Office engineered to carry very heavy loads. In the rear southeastern quadrant (five bays wide by four bays deep), the press room flooring was reinforced by the four-way system initially developed ca. 1902-08 by Boston and Minneapolis engineers Orland W. Norcross and C.A.P. Turner. The four-way systems in most general use by the early 1920s were the Cantilever Flat Slab System and the Simplex System. These two patented systems had the same arrangement of reinforcement, but differed in placement of chairs and spacing bars (methods of holding the reinforcing in place).[2] The four-way systems consisted of four bands of small diameter steel bars evenly placed and parallel to one another running lengthwise, crosswise and in both diagonal directions across the floor panels from column to column as well as across the columns. Application of the four-way system differed as to which bars were bent up over the column heads. In some applications of the four-way system bars from all four bands were bent up at the column heads; standard recommendation by 1919 was for only bars in the two diagonal bands to be bent up. In the Press Room, only the diagonal bands were bent up at the column heads. The bent bars provided tensile reinforcement while the two lengthwise and crosswise bands of bars continued across the column through the bottom of the slab to provide compressive reinforcement.[3]

For the remainder of the first floor and all of the second floor (designed for storage, bindery, and limited offices), the two-way system reinforces the flooring. Developed by Chicago engineers Theodore L. Condron and Frank F. Sinks of the Condron Company under the trade name Acme System, and by the Corrugated Bar Company under the trade name Corplate (ca. 1909-12), the two-way system was the second major historical engineering system the engineers experimented with during the early twentieth century. It was the Acme System that was employed in the State Printing Office. In this two-way system, belts of reinforcing bars extend crosswise and lengthwise from column to column and across the columns. Bars are bent to reinforce the bottom portion of the slab between columns and the upper portion around the columns. Bars carried through the slab provide compressive reinforcement; bars bent up over the columns provide negative bending moment reinforcement.[4]

Throughout the State Printing Office the concrete flooring slabs were the heavy slab type appropriate for the four-way and two-way reinforcing systems. Between ca. 1908 and 1925 depth of such slabs varied from as much as twelve inches to as little as four inches. The slabs in the State Printing Office are 8 3/4 inches in depth, a size frequently found in slabs used between 1916 and 1918. This thickness was quite conservative when compared with engineering recommendations of 1919 and especially when compared with those of 1925. In 1919 Taylor and Thompson recommended that slabs be no less than six inches or 1/34 the length of the panel span, column to column, with the sum of live and dead loads considered in the calculation (<u>Concrete Plain and Reinforced</u>, third edition, 1919). In 1925 Taylor and Thompson recommended no less than four inches or 1/45 of the interior span with loads of 100 pounds per square foot or under, and 1/36 of the interior span with loads over 100 pounds per square foot. For the State Printing Office such calculations would have rendered a slab depth of six to seven inches by 1919 recommendations and four to seven inches by 1925 recommendations.[5] Slab thickness was typically considered independently of the drop panel system often used with it. All these calculations were experimental when compared to engineering specifications of the years that followed.

Most reinforced concrete flat slab flooring systems after 1912 incorporated a square or rectangular concrete drop panel to further thicken the slab over the columns to absorb the high shearing stresses at the column heads. The 1909-12 forerunner to the drop panel was a broad shallow beam, or continuous panel (band) that ran from column to column across column heads, usually in one direction only. Use of square panels over columns was called the drop slab system, and use of continuous bands over and between columns were called slab bands. In period journals and other discussions, use of the drop-slab system or the slab-band system was interpreted as a wise experimental precaution against little understood types of structural failure.[6] The drop panel itself was referred to as the "depressed head", the "plinth" (a term borrowed from column terminology in Classical architecture), or the "drop".

Standardized recommendations existed and were generally adopted for the dimensions of the drop panel. In 1914 and again in 1919 the recommendation was a drop panel width of 4% of the span and a thickness of 6% of the slab depth. By 1925 more sophisticated formulas existed.[7]

In the State Printing Office two sizes of drops were employed. For the four-way reinforcing system of the first floor Press Room, drops located in the basement are five and one-quarter inches deep by seven feet six inches square. Total slab depth at the column heads throughout the first and second floors is 14 inches.[8] The thickness of the drop panel in the State Printing Office is exactly the standardized 6% of slab depth recommended by engineering manuals of 1914-19, while the width of the drop panel is only slightly smaller than these same period recommendations. By 1914-19 calculations the drop panel horizontal dimensions should have been about eight feet square for those drops used in conjunction with two-way system and proportionally smaller for those used in conjunction with four-way system reinforcing.

The rationale for using two sizes of drop panels in the State Printing Office must have been based on the differing sizes and spacing used for the basement columns under the Press Room. For the entire first floor and second floor the bay system created by column placement was 20 feet 1 inch wide by 19 feet 4 inches deep. However, under the Press Room floor the bays had an extra column placed in the center of each panel. Thus, although the axial distance between spans remained the same, the placement of an off-set column in the center of the panel effectively reduced the distance between any two columns to approximately 14 feet. Drop panels for this flooring section are also set on the diagonal, juxtaposed with the axial placement of the larger drops used elsewhere throughout the building. Undoubtedly this was done to accommodate a continuation of the two-way system reinforcing bands and the addition of smaller diagonal bands in the Press Room itself to create the isolated four-way system there. Bay dimensions of approximately 20 by 20 feet are entirely typical for the period. The added center columns in the basement section under the Press Room bays indicate a conservative approach to concentrated heavy weight in this section of the structure. Height for the State Printing Office bays is 10 feet for the basement, 16 feet 8 inches for the first floor and 17 feet 3 inches for the second floor, also typical for the period.[9]

In addition to the individual drop panels used throughout the structure, several systems of continuous drop panels are used for portions of the State Printing Office that had especially heavy projected loading. For the first floor framing system the two rear southeastern corner bays have two bands of continuous drop paneling, north to south, and one band east to west. This was to be the location of the future magazine press. For the rear southwestern corner, the sixth and seventh bays north to south and the seventh and eighth bays east to west, the four bay area is reinforced with a tee-shaped set of continuous drop panels. This was the flooring for the loading dock. Finally for the first floor system, the first through sixth facade bays along O Street, east to west, have continuous drop paneling north to south one bay deep, with the northeast corner reinforced with continuous drop panels east to west and north to south.

For the second floor framing system, three areas are reinforced with continuous drop panels. The entry stairwell of facade bay seven, east to west, is reinforced with a partial continuous drop panel along the southern edge and a full continuous drop panel along the western edge. Along the eastern edge of the seventh bay, east to west, and the fourth bay, north to south, a continuous drop panel reinforces the second floor restroom area. The southwestern rear corner above the loading dock area, bays seven and eight east to west, north to south, is reinforced with a double-tree configuration of continous drop panels. The second floor was built for storage space, an office and a bindery: presumably, the bindery was located in the southwestern rear corner and the office in the northwestern corner with the remainder of the floor initially used as storage space for printed matter and books.[10]

The final component of the reinforced concrete flat slab system was the column, usually referred to as a mushroom column due to its flared and distinctive capital. The flat slab system was alternately described as column-and-slab framing to emphasize the two critical features of mushroom column and flat slab. Engineer Claude Allen Porter Turner (C.A.P. Turner) of Minneapolis invented the mushroom column and its first system application (without drop panels) in 1905.[11] Initially, column formwork was cast iron and overly detailed with ornamental flourishes. (Drop panels has also been initially octagonal or hexagonal for architectonic purposes as well.) Very early on, preferred formwork came to be reusable sheet metal; sheet metal could be greased with paraffin oil to keep the drying concrete from sticking (and to facilitate formwork removal), and it could be battered back into the desired shape easily if necessary. Sheet metal formwork was also inexpensive.[12] In the State Printing Office the columns themselves still show the sheet metal formwork seams, while the flared capitals show the riveted individual plate marks of the capital forms. The drop panels and flooring itself used wood forms in the State Printing Office; form board marks for panels and flooring are entirely visible. Wood forms for these two components were the rule.

Mushroom columns also had recommended engineering specifications, 1919-25. Angle of the mushroom capital was typically recommended to be no less than 45 degrees, with standardized specifications of a column head diameter of 22.5% of the interior span. These specifications are precisely present in the mushroom capitals of the State Printing Office: the column head diameter for the columns placed with the 20 feet 1 inch by 19 feet 4 inch bays is four feet six inches. The columns themselves were sometimes square, octagonal, rectangular or oblong in cross-section, but when metal formwork was used they were typically round, as in the State Printing Office. Column diameter specifications were based on estimated live loads and span length. The diameter of 21 inches for the basement columns of the State Printing Office correspond to a projected live load (in 1925 specification terms) of approximately 210 to 300 pounds per square foot for the first floor outside the Press Room, 21 inches being about 1/12 of the 20 feet 1 inch span length.[13] For the second floor, an 18 inch diameter for first floor columns corresponds to a projected live load of about 200 pounds per square foot. For the added center columns located in the center of each 20 feet 1 inch by 19 feet 4 inch bay under the Press Room, columns are 18 inches in diameter with 3 feet 3 inch column heads.

Reinforcing for the columns was typically spiralled steel rod hooping with vertically placed reinforcing steel rods. In the State Printing Office 3/8 inch rod hooping is sprialled at a 2 1/2 inch pitch, with nine 1 I/8 inch vertical rods placed I I/2 inches in from the outer edge of the 2I inch column. For the 18 inch columns wire hooping was used, with 9 7/8 inch rods.[14]

The State Printing Office is an eight by eight bay structure (bays 20 feet I inch wide by 19 feet 4 inches deep). In the basement, 37 interior reinforced concrete mushroom columns of 21 inches diameter, and 32 interior reinforced concrete mushroom columns of 18 inches diameter, both with drop panels and some continous drop panels, support the first floor slab. In the first floor space 49 interior reinforced concrete mushroom columns of 18 inches diameter with drop panels and some continuous drop panels, support the second floor slab. The third floor framing system was intended to be removed at a later date for the addition of one or two floors. Thus the third floor framing system (the columns present on the second floor and the ceiling/roofing of the second floor) is a wood-frame type with wood beams and girders.

2. Engineering History for Reinforced Concrete Column-and-Flat Slab Flooring Systems, 1902-32

By the turn of the 20th century reinforced concrete beam-and-girder systems had come into prominence for industrial buildings with heavy loading. Warehouses, mercantile buildings and factories were most commonly designed and engineered with the reinforced concrete beam-and-girder system. One of the best illustrated discussions of state-of-the-art reinforced concrete beam-and-girder systems at the turn of the century was Emil Morsch's Concrete-Steel Construction, first published in German in 1902 and translated with American publication in 1909. Morsch illustrated excellent examples of recently built structures with reinforced concrete beam-and-girder systems with photographs of interior spaces: a spinning factory in Tammerfors, Finland; and in Germany, a storehouse in Ulm, a printing house in Heibronn; the Singer Manufacturing Company in Wittenberg; and a warehouse in Krefeld.[15] The third edition of Charles H. Marsh and William Dunn's Reinforced Conrete of I906 (first edition, 1905) listed 41 reinforced concrete beam-and-girder systems currently in use in the United States, France, Germany, England, Italy, Austria, Hungary, Holland and Switzerland, a summary listing of all international work.[16] The reinforced concrete beam-and-girder system replaced the steel frame which was itself a translation of an earlier framing system in cast iron and wood. However, in order to accommodate the heavy loading demanded by then contemporary use, the reinforced concrete beam-and-girder system became extremely awkward in cross-sectional dimensions. The depths and widths of very large girders and beams consumed valuable interior space and made the overall dimensions of structures excessive.

The transition to a flat slab system regained the interior space that had been lost to beams and girders. A full additional floor of space could be regained in some muti-story buildings and a ten percent gain in interior space was typical with the use of the flat slab system. Light and ventilation for the interior was also greatly improved.

In the column--flat slab system, a flat slab supported by more than two equally spaced columns (both of reinforced concrete) behaves as a flat dome or as a series of continuous beams in rectangular and diagonal directions. The slab tends to bend downward over supporting columns, with compressive and tensile stresses behaving in particular patterns in different sections of the slab. The column-flat slab problem is essentially similar to the column-footing problem turned upside down. To handle the stresses perceived and later tested for, the column capital was flared, the slab was thickened around the column and several types of reinforcing were tried. Experiments and patents for footing reinfocement in 1900 in the U.S. led to the first patent for radial slab reinforcement across a column by O.W. Norcross in 1902, a patent for a system he placed in a building the preceding year.[17]

The year 1905 marked the beginning of accelerated interest in reinforced concrete generally, as well as the specific innovation of the column-flat slab system using reinforced concrete. In 1905 Marsh and Dunn's <u>Reinforced Concrete</u> was quickly followed by the first edition of Frederick W. Taylor and Sanford E. Thompson's <u>A Treatise on Concrete Plain and Reinforced</u> Taylor and Thompson would later update their <u>Concrete Plain and Reinforced</u> in 1909, 1919, 1925, and 1932 in five editions that were considered the standard engineering references for reinforced concrete. The first substantial innovation in the column-flat slab system was that of Minneapolis engineer C.A.P. Turner in 1905. Turner first proposed his "Mushroom System" of concrete reinforcement in <u>Engineering News</u>, October 12, 1905, preceding it with an editorial referring to Marsh and Dunn's <u>Reinforced Concrete</u> the week before. Turner introduced a column-flat slab system with four-way reinforcement bands in the slab with concentric and radial reinforcement over the column. A flared column head for the column itself became the hallmark feature of the system. No continuous drop panel or individual drop panel was employed at this 1905 stage.[18] The five-story C.A. Bovey Building (a warehouse) in Minneapolis was the first structure to incorporate Turner's mushroom column-flat slab system. Turner patented the system in 1908 and thereafter his system was known as the Mushroom System. Initially it was the only column-flat slab system actively used and so was not referred to as a four-way system.[19] In 1908 international engineers began to follow the U.S. developments in 1902-08 when French engineer Richard Maillart experimented with beamless concrete slab flooring in 1908. Architectural historian Siegfried Giedion cited a Maillart warehouse in Zurich as the "first mushroom ceiling in Europe".[20]

Turner's Mushroom System was the main column-flat slab system until about 1912-14. His own publication entitled <u>Concrete Steel Construction</u> was published in 1909, with a co-authored <u>Concrete Steel Construction</u> published in 1914.[21] By 1909, however, two other leading American engineers, T.L. Condron and F.F. Sinks, developed two-way reinforcement which became the second major column-flat slab system. In this system continuous drop panels and then individual drop panels were added. The two-way system of reinforcing bands replaced Turner's radial bars over the capital heads, while the drop panels thickened the floor slabs in those areas of greatest stress. The first Condron drop-slab building was the grocery warehouse of Sears, Roebuck and Company in Chicago of 1912. Between 1912 and 1915 Turner's mushroom column-flat slab system was still actively used but began to be replaced by the more generically known four-way system. By 1925, Taylor and Thompson in Concrete Plain and Reinforced noted of Turner's Mushroom System: "At present it is used but little, if at all, because the features distinguishing it from ordinary four-way systems are either useless or harmful." Variations of the trade name four-way systems were also mentioned: Mushroom System, Cantilever Flat Slab System, Simplex System, and Barton Spider Web System.[22] In addition to the post-Turner four-way systems, the Condron two-way system became widely used between 1915 and 1920.

The four-way and two-way systems still faced much skepticism from the engineering field between 1911 and 1914. Tests of beam-and-girder systems versus tests of flat slab systems were frequent and much discussed. Reinforced beam-and-girder systems were predominant in the professional journals.[23] However, during 1914-16 many articles appeared discussing the new variety of flooring systems and on August 18, 1914 the building commissioner for Chicago issued a ruling on the design of reinforced concrete flat slab floors. The Chicago Ruling was the first of many and was immediately published in Engineering News. For the first time uniform standards or rules existed for the engineering and design of each possible component for the column-flat slab system. By 1924, Chicago and New York Flat Slab Regulations as well as the Joint Committee Specifications of the American Concrete Institute were all solidly in effect by 1924.[24]

Meanwhile, new reinforcing systems were coming to the forefront. Late in 1914, the Morrow three-way system made its appearance.[25] In 1915 the S-M-I System (also known as the Circumferential or Smulski System) appeared in reinforced concrete flat slab construction in the eastern seabord states. The S-M-I System, developed by Boston engineer Edward Smulski, was a totally new idea in reinforcing systems, employing circumferential and radial reinforcement units with only a small amount of steel running between the columns. By 1918 and 1919 the S-M-l System was receiving substantial professional attention.[26]

Tests and counter-tests for the vying systems continued after 1918, but there were very few articles on flooring systems, per se, after 1918. Following the international recovery from the first world war, emphasis seemed to shift to architectural design, with exterior and interior design applications incorporating the accepted flooring systems, most commonly the two-way system. (The four-way system in any form became increasingly less used; the three-way and S-M-I systems were always considered somewhat exotic.) Structures designed for heavy loading increasingly incorporated classical bay facades that were stripped and streamlined of architectonic classical ornament. The interior wide span open bays with large panels of windows were already reflected in the exterior facades. An excellent example of these modern structures with a new integration of engineering and design appeared in Concrete in December 1920.[27] Architectural historian Peter Collins specified the year 1927 as "a highly significant year in the development of interest in concrete architecture, and may be considered as marking the period when reinforced concrete obtained general acceptance and recognition in the more progressive architectural circles in various parts of the world." Collins further noted that 1927-28 witnessed the publication of five major architectural (as juxtaposed to engineering) studies of modern reinforced concrete buildings in English, French and German.[28]

Among Collins's five noted studies, T.P. Bennett and F.R. Yerbury's Architectural Design in Concrete of 1927 cited "Mushroom Construction" as one of the very significant engineering innovations affecting interior architectural space: "The principal advantage secured in this case is the elimination of deep beam projections which would obstruct the light. The column is still somewhat massive as a result of the loads to be carried, and there is no doubt room for the invention of steel and cement [reinforced concrete] of even greater carrying capacity, which will allow the dimensions of future columns to be reduced." Bennett and Yerbury illustrated their discussion with the Shredded Wheat Factory designed by architects L. de Soissons and A.W. Kenyon at the second British garden city of Welwyn.[29] Welwyn was a post-1919 planned town that was intended to reflect the ideas and ideals of Ebenezer Howard, turn-of-the-century originator of the garden city concept. Welwyn provided not only examples of avant-garde garden city socio-economic tenets, layout and buildings, but also examples of avant-garde structural technology and industrial design. The Shredded Wheat factory's exterior facade highlighted a simplified wide bay system of fenestration panels and vertical pilasters. The interior accented open space, light and ventilation, with facted octagonal mushroom columns, drop panels and reinforced concrete flooring. Of course, the reinforced concrete column-and-flat slab engineering systems made possible an integrated exterior and interior design, illustrating how architectural design itself had begun to really take advantage of technology and move in new directions.

Within the international sphere of reinforced concrete historic engineering developments generally, and within the U.S. developments in particular, the flooring system in the California State Printing Office in Sacramento was conservative for its construction date in 1922. The combination of both four-way and two-way systems, as well as the use of some reinforced concrete beam-and-girder units, continuous drop panels and individual drop panels, made the flooring system evocative of avant-garde technology ca. 1912-14. The Spanish Colonial Revival and generic classical detailing of the exterior facade of the California State Printing Office also was conservative for 1922, albeit internationally architectural design for such buildings changed more quickly during the late teens and twenties than did design in the United States.

Perhaps most difficult to evaluate is the frequency of use of this type of reinforced concrete column-and-flat slab flooring systems regionally and state-wide. A few such buildings were illustrated and discussed in Architect

<u>and Engineer</u> (of California) of 1922-25. Two examples were the San Francisco Ford Agency (William L. Hughson Building) of ca. 1922 and the Pacific Coast Borax Plant (ca. 1925) on Mormon Island in Los Angeles harbor. For the Ford Agency structure, mushroom columns with individual drop panels for the automobile showroom and a combination of continuous and individual and drop panels for the assembling plant were illustrated. For the Borax Plant structure, mushroom columns with individual drop panels only were illustrated. In both cases no mention was made of the specific flooring system(s) used. Exterior designs were vaguely classical, as would have been appropriate for the engineering system in its first years.[30] It seems probable that the technology and design for the California State Printing Office were regionally typical for multi-story structures intended for heavy dead and live loads ca. 1922, and that in general, regional technology and design for these types of buildings were conservative in the larger national and international settings for 1922.

Prepared by : Karen Weitz
Title : Architectural Historian
Affiliation : Consultant to State of California
Department of General Services
Office of Project Development and Management
400 R Street, Suite 5100
Sacramento, CA 95814
Date : August 1989

Notes

The reference source for Part 1 and Part 11A is the "Study of the Existing Buildings on the Department of General Services Site 7, Sacramento, CA - Architectural and Historic Significance," by Karen Weitze which is Appendix B of the Draft Environmental Impact Report: Site 7 Complex for the California Secretary of State and the California State Archives, SCH #88020818, August 1988. References for Part 11B are listed below.

[1]George B. McDougall, "State Printing Office," ink-on-linens, August 19, 1922; "First Floor Framing Plan", Sheet S-2; "Second Floor Framing Plan", Sheet S-3; "Details of Flat Slab Construction", Sheet S-9. For first floor planned use, see the full set of ink-on-linens held for the State Printing Plant (filed as the Archives Building), dated August 19, 1922 at the California Office of the State Architect, vault. Also see, "State Printery Largest in West", Sacramento Bee, February 19, 1927, p. A-1, c. 1-5.

[2]Carl W. Condit, American Building Art; The Twentieth Century, New York: Oxford University Press, 1961, pp. 167-68; Frederick W. Taylor, M.E., and Sanford E. Thompson, S.B., A Treatise on Concrete Plain and Reinforced, third edition, New York: John Wiley & Sons, 1919, pp. 541-42; George A. Hool, S.B., and W.S. Kine, S.B., Reinforced Concrete and Masonry Structures, New York: McGraw-Hill, 1924, pp. 271-272; Frederick W. Taylor, S.E. Thompson and Edward Smulski, C.E., Concrete Plain and Reinforced, fourth edition, v.1, New York: John Wiley & Sons, Inc., 1925, pp. 358-59. The Taylor and Thompson updated editions remained significant as standardized references for reinforced concrete throughout the 1905-32 period. See note 18.

[3]Taylor and Thompson, Concrete Plain and Reinforced, third edition, 1919, p. 541.

[4]Condit, American Building Art, p. 168; Taylor and Thompson, Concrete Plain and Reinforced, third edition, 1919, p. 542; Hool and Kine, Reinforced Concrete and Masonry Structures, 1924, pp. 267-72; Taylor, Thompson and Smulski, Concrete Plain and Reinforced, fourth edition, v. 1, 1925, pp. 362-67.

[5]For the standardized slab thickness recommendations: Taylor and Thompson, Concrete Plain and Reinforced, third edition, 1919, p. 551, and Concrete Plain and Reinforced, fourth edition, v.1, 1925, pp. 325-27. For discussions of slabs actually constructed 1908 to 1918: "New Freight Depot," Engineering Record, v. 57, #12, March 28, 1908, p. 374; "Erecting a Heavy Warehouse," Engineering News, v. 71, #11, March 12, 1914, pp. 568-70; "Extensometer Tests on Three Types of Concrete Floors," Engineering News, v. 75, #21, May 25, 1916, pp. 992-93; "Circular Reinforcing the Design Feature of a Paper Factory", Concrete, v. 12, #3, March 1918, p. 75. Slab depths discussed from these actual examples varied from 11 3/4 inches (1908 article) to 7 1/2 inches (1918 article).

[6]Condit, American Building Art, p. 168.

[7]Henry T. Eddy, C.E., Ph.d., Sc.D., and C.A.P. Turner, C.E., Concrete-Steel Construction: Part I - Buildings, Minneapolis: H.T. Eddy and C.A.P. Turner, 1914, p. 156; Taylor and Thompson, Concrete Plain and Reinforced, third edition, 1919, p. 551, and Concrete Plain and Reinforced, fourth edition, v. 1, 1925, pp. 322-25, 339ff.

[8]McDougall, "Details of Flat Slab Construction," Sheet S-9.

[9]George B. McDougall, "State Printing Office," August 19, 1922: "Column Schedule," Sheet S-13 and Sheet S-14.

[10]Condit, American Building Art, pp. 167-68.

[11]Eddy and Turner, Concrete-Steel Construction, 1914, pp. 45-48.

[12]Taylor and Thompson: Concrete Plain and Reinforced, third edition, 1919, p. 551; Concrete Plain and Reinforced, fourth edition, v. 1, 1925, pp. 305-07, 320-22. McDougall, "Column Schedule," Sheet S-13.

[13]Eddy and Turner, Concrete-Steel Construction, 1914, p. 159; McDougall, "Details of Flat Slab Construction," Sheet S-9, and "Column Schedule," Sheet S-13 and S-14.

[14]See the full set of ink-on-linens held for the State Printing Office (filed as the Archives Building), dated August 19, 1922, at the California Office of the State Architect, vault. For continuous drop slab details, see Sheets S-2 and S-3. Also, "State Printery Largest in West," Sacramento Bee, February 19, 1927, p. A-1, c. 1-5.

[15]Condit, American Building Art, pp. 166-68; Tovell Marston, "Why a Reinforced Concrete Building is Best...in Favor of Flat Slab Construction," Concrete, April 1917, pp. 142-44; Emil Morsch, Concrete-Steel Construction, New York, 1909 (first published in German in 1902), pp. 214, 220, 226, 228.

[16]Charles F. March and William Dunn, Reinforced Concrete, third edition, New York: Van Nostrand Co., 1906, pp. 30-117; Peter Collins, Concrete: The Vision of a New Architecture, New York: Horizon Press, 1959, p. 115. Collins notes that C.F. March's Reinforced Concrete (1905) was the first English engineering treatise published on reinforced concrete.

[17]Condit, American Building Art, p. 167.

[18]Taylor and Thompson, Concrete Plain and Reinforced, first - fifth editions, 1905, 1909, 1919, 1925 and 1932; Condit, American Building Art, pp. 167-68; Engineering News, v. 54, #14, October 5, 1905, and, v. 54, #15, October 12, 1905. Prior to the Mushroom System, C.A.P. Turner patented a reinforced concrete flat slab system carried by girders without stiffening

beams or ribs: see, "Reinforced Concrete Warehouse for Northwest Knitting Co., Minneapolis, Minn.," Engineering News, v. 53, #23, June 8, 1905, pp. 593-95. Taylor and Thompson's section on concrete flooring, 1905, treats only beam and girder types: pp. 450-59.

[19]Condit, American Building Art, p. 168; "A Test of a Warehouse Floor," Engineering News, v. 56, #14, October 4, 1906, pp. 361-62; F.E. Turneaure, Principles of Reinforced Concrete Construction, New York: J. Wiley & Sons, 1908, pp. 258-59.

Other discussions of the innovative Mushroom System include: Engineering Record: "New Freight Depot of the Wisconsin Central Ry. at Minneapolis," v. 57, #12, March 28, 1908, pp. 374-75; "The Bostwick-Braun Building, Toledo," v. 57, #18, May 2, 1908, pp. 575-78. The true Turner Mushroom System did not use continuous drop panels or drop panels. By 1915, Turner, like several engineers of these years, continued to patent other systems or variations. One example of Turner's from 1915 was for a two-way system with a round spiral (steel rod) placed over the column head, and diagonal bands running from midspan to midspan not touching the column heads--this system (brief lived) was called the "Spiral Mushroom." Engineering News, "Test of a Peculiarly Designed Concrete Slab," v. 73, #22, June 3, 1915, p,. 1070, and "New Flat-Slab Floor," v. 74, #3, July 15, 1915, p. 144.

[20]Sigfried Giedion, Space, Time and Architecture, fourth edition, Cambridge, Mass: Harvard University Press, 1973, pp. 452-53.

[21]An excellent bibliography of early discussions of mushroom column-and-slab framing appears in Eddy and Turner, Concrete-Steel Construction, 1914, p. 161.

[22]Taylor and Thompson, Concrete Plain and Reinforced, fourth edition, 1919, pp. 359-62.

[23]See Cement Age, v. 10, #4, April 1910; v. 12, #2, February 1911; v. 14, #4, April 1912. Also Cement Age, v. 12, #1, January 1911, for tests of flat slab systems, pp. 31-38.

[24]Engineering Record: "When Doctor Disagrees," v. 77, #8, February 22, 1917, p. 327; "Chicago Reinforced-Concrete Flat-Slab Ruling Amended," v. 79, #25, December 20, 1917, pp. 1153-55; "New York City Concrete Flat-Slab Regulations," v. 85, #7, August 12, 1920, p. 300-02. Hool and Kine, Reinforced Concrete and Masonry Structures, 1924, and, Taylor and Thompson, Concrete Plain and Reinforced, fourth edition, v. 1, 1925.

[25]"A New Flat-Slab Reinforced Concrete Floor with Striking Features," Engineering News, v. 72, #25, December 17, 1914, p. 1214; Hool and Kine, Reinforced Concrete and Masonry Structures, 1924, pp. 275-76; Taylor and Thompson, Concrete Plain and Reinforced, fourth edition, v. 1, 1925, pp. 374-75.

[26]Concrete: "What S-M-I Flat Slab System Means," v. 12, #2, February 1918, p. 61; Edward Smulski, "Circular Reinforcing the Design Feature of Paper Factory," v. 12, #3, March 1918, pp. 75-77; Edward Smulski, "Tests of Circumferentially Reinforced Floor," v. 13, #9, September 1918, p. 85. Also, Taylor and Thompson, Concrete Plain and Reinforced, third edition, 1919, pp. 542-44; Hool and Kine, Reinforced Concrete and Masonry Structures, 1924, pp. 276-78; and major explication in Taylor, Thompson and Smulski, Concrete Plain and Reinforced, fourth edition, v. 1, 1925, pp. 367-74.

[27]G.W. Maker, "Concrete Building Interiors," Concrete, v. 17, #6, December 1920, pp. 179-81.

[28]Collins, Concrete, 1959, p. 127. Collins listed T.P. Bennett and F. R. Yerbury's Architectural Design in Concrete, Paul Jamot's A. & G. Perret et l'Architecture du Beton Arme, the English translation of Le Corbusier's Vers Une Architecture, Francis S. Onderdonk's The Ferro-Concrete Style in preparation for U.S. publication) and Vischer & Hilberscheimer's Eisenbeton als Gestalter (in preparation in Germany), as the critical 1927 architectural studies. Publication dates actually ranged over 1927-28.

[29]T.P. Bennett and F.R. Yerbury, Architectural Design in Concrete, New York: Oxford University Press, American Branch, 1927, pp. 14-15, and plates LVII and LVIII.

[30]Architect and Engineer: v. 68, #3, March 1922, p. 125; "New San Francisco Home of Ford Agency," v. 70, #2, August 1922, pp. 112-13; "Pacific Coast Borax Plant a Notable Industrial Achievement," v. 80, #3, March 1915, pp. 81-82.