latter city, where its progress was more gradual but not the less certain. Streets a hundred feet wide offered no obstruction to the fire spreading, for the intense heat of the redwood caused the buildings opposite to ignite as soon as the fire gained requisite strength. On Mission Street wood construction predominated, and with this street as an axis the conflagration spread in other directions. Had there been no redwood the business district might have been saved.

Among the more prominent buildings destroyed, taking them in regular order, was the New Merchants' Exchange, finished January 1, 1905, fourteen stories in height and of steel construction, faced with granite on the first floor and with terra-cotta brick for those above. The earthquake caused the building but incidental damage, but fire subsequently gutted it completely. It is now believed that the frame of the structure is intact and can be used again. The terra-cotta is apparently but little injured.

The Union Trust Company's bank, at Market and Montgomery Streets, fifteen stories, lately completed, steel frame, terra-cotta facing, will be occupied for business in a few days, as, the writer is informed, will the Crocker Building, opposite, of like construction, which stands but little injured, apparently only needing new finishing for the inside.

The Palace Hotel was built before the adoption of steel-frame construction, but with solid brick walls which stand and can be made available if desired.

The new Chronicle Building, unfinished, sixteen stories, steel and terra-cotta, will be as good as new with interior furnishings replaced; the old part, however, fifteen years old, steel and brick, is in a precarious condition and will probably have to be demolished.

The lofty Call Building was subjected to an intense redwood flame, but stands upright and majestic. The Colusa sandstone with which the structure was faced is badly disintegrated by heat, but the frame is said to be intact and may be used again.

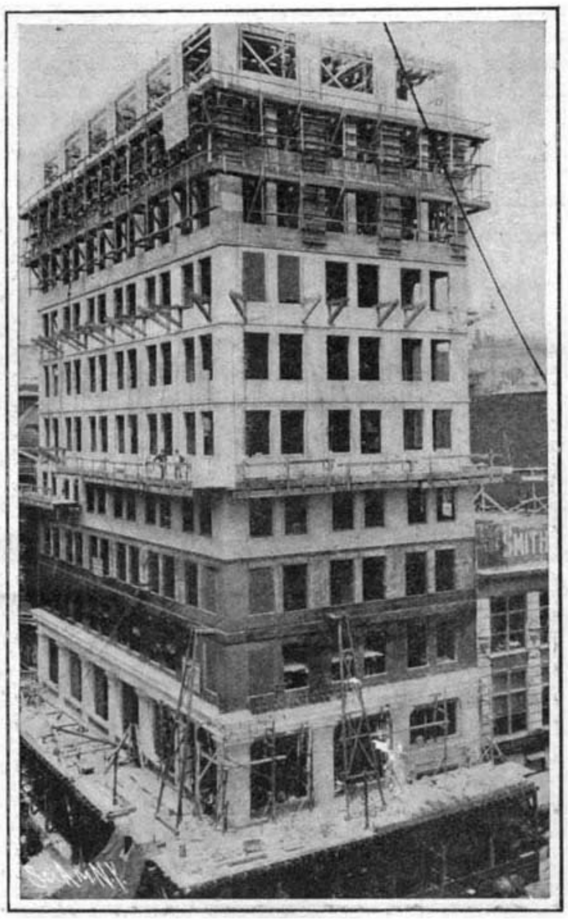
The James L. Flood Building, Market and Powel, just completed at a cost of $2,500,000, was badly gutted, though the steel frame is in perfect condition as far as can be judged. This building was faced with Colusa sandstone, which offered but little protection owing to the intense heat.

The Ahronsen Building at Mission and Third Streets, finished one year ago, ten stories, steel frame, terra-cotta brick faced, with interior replaced will be good as new, though not subjected to the intensest heat, as it was surrounded with low buildings in every direction.

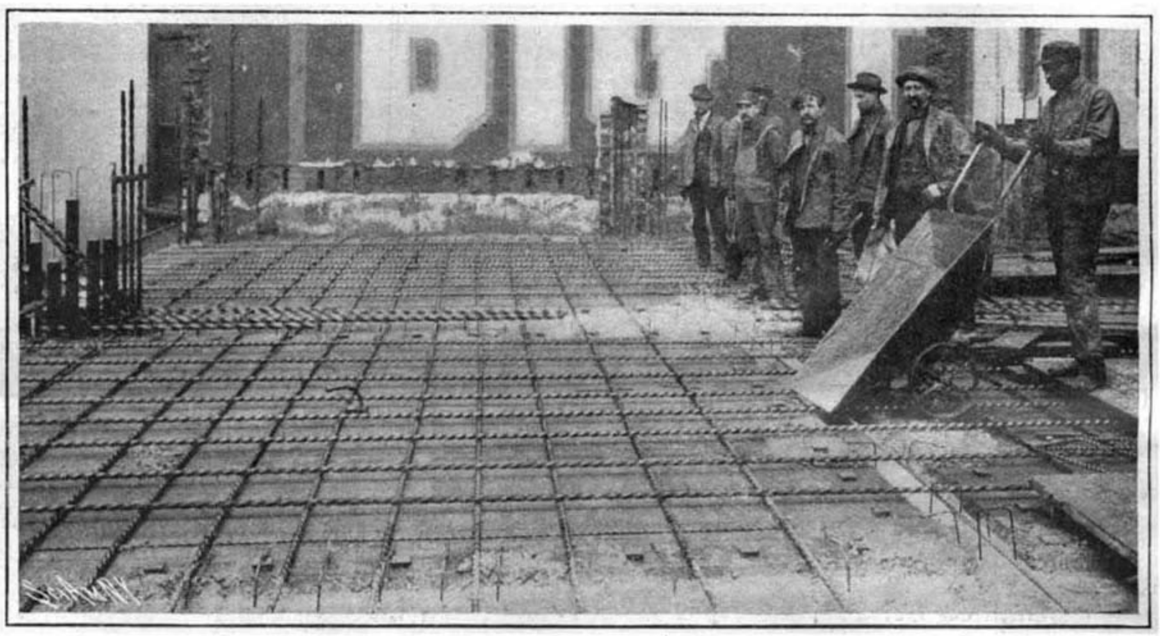
The "Fairmount," of steel and terra-cotta, unfinished, is comparatively little injured, and with interior renovated can soon be occupied.

With these examples it would appear that terra-cotta is far and away the best exterior material for buildings of any height. No stone that was ever quarried can withstand the intense heat of a general conflagration. Though ordinary clay brick of good quality is almost equal in fire-resistance to terra-cotta, as proof against an earthquake shock brick is no better, if as good, as stone.

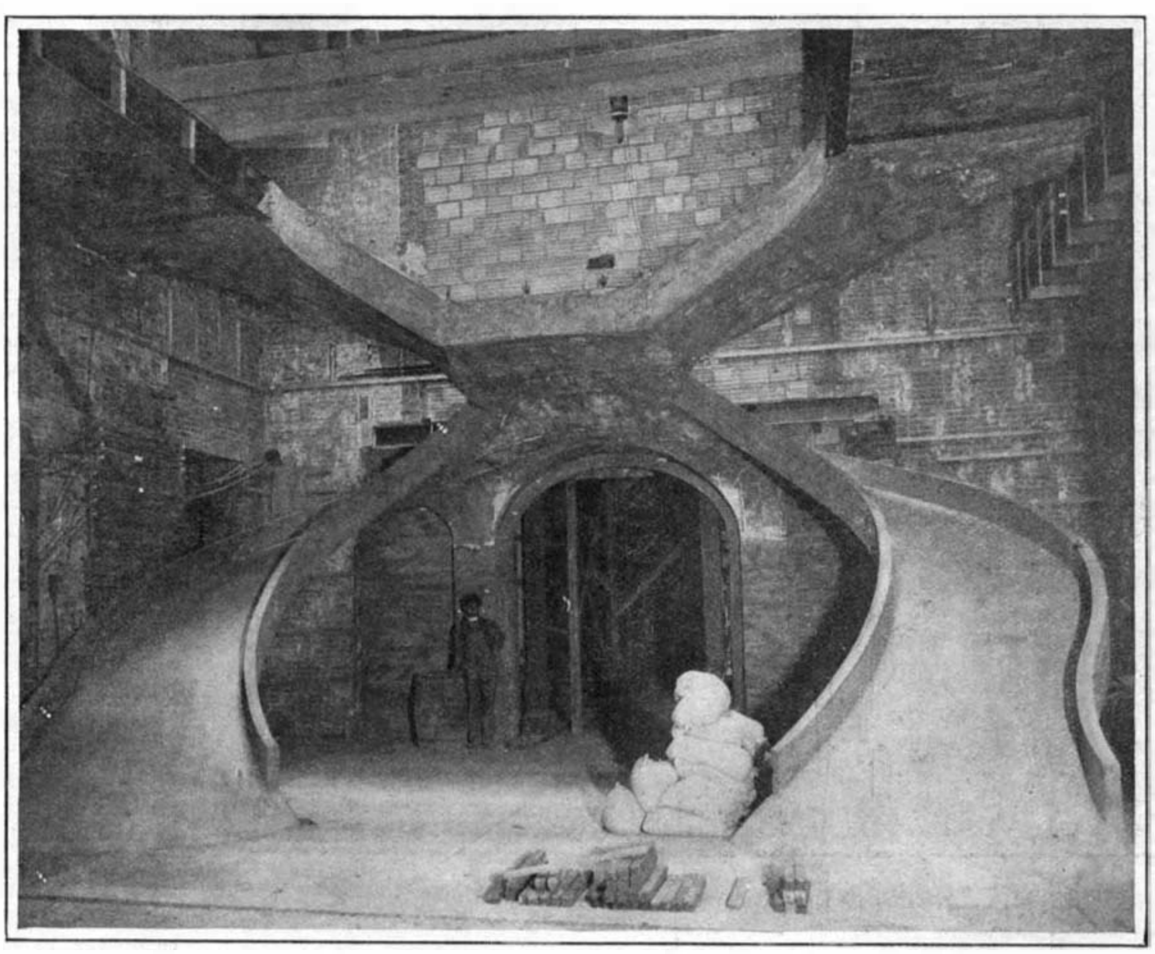
Brick and stone buildings of the past were useless, and as easily demolished in the San Francisco fire as a paper box.



THE INGALLS BUILDING—COMPLETING THE ELEVENTH FLOOR.



THE INGALLS BUILDING—THE STEEL REINFORCEMENT FOR THE FLOORS.



CONCRETE STAIRWAY CONSTRUCTION IN THE NEW YORK HOUSE OF G. W. VANDERBILT.

A STAIRWAY OF REINFORCED CONCRETE.

One of the possibilities of reinforced concrete is interestingly shown in the accompanying illustration from photograph taken during the construction of the main stairway in the New York house of Mr. George W. Vanderbilt. The stairway was designed by Hunt & Hunt, architects, and was built by the Turner Construction Company as sub-contractors. In the engraving the body structure of the stair is shown completed, but without the treads, sides, rails, etc. The stair is double, two branches starting from the ground floor, and rising in graceful reverse curves to meet at a landing somewhat more than half way to the story above. At the point of meeting of the two branches the stair touches the wall toward which the two lower branches curve, and is supported by the wall at the point of contact. Two branches again start from the landing, curving in a direction transversely across the corresponding lower arms to the floor above. The entire stair is supported at only one point between the floors, and that is where it abuts against the wall. All intermediate columns have thus been avoided, for these would not have been in harmony with the design. Had the stair been built of steel, it would have been impossible to obviate the intermediate supports except by making the structure exceedingly heavy and bulky, a feature which would have been objectionable.

The construction is on the Ransome system, in which the concrete is reinforced by longitudinal and transverse bars of twisted steel carried into the supports where necessary, and with the individual members, where possible, tied together by wire. The longitudinal bars, both in the body and the sides, are bent to conform to the curvature of the stair, and are continuous from the intermediate landing to the floor above and the floor below. The transverse rods are spaced short distances apart, and have their ends bent at right angles to project into the lateral flanges, clearly shown in the photograph. The concrete construction is carried out to engage with the I beams in the wall and at the second floor landing, and thus is formed an extremely solid bond. The design is not considered by engineers a difficult one to execute, notwithstanding that the result is rather a freak structure. It merely proves that it is possible to build anything of concrete for which a mold can be constructed and set up, and that with the steel reinforcement the resulting structure is not only strong, and solid, but is often less cumbersome than a corresponding one built entirely of metal. In the present case, if the stair had been built of steel, it would have been necessary to design and manufacture each piece separately, with a consequent loss of time and at greatly increased expense.

The stair is designed for a live load of about 150 pounds per square foot, and was found to answer all requirements in a thorough series of tests, in which heavy bags of cement were dropped upon it at various points from a height of some 12 feet. The stairway was finished in white marble with brass railings, and the structure has turned out to be not only a pre-eminently practical one, but an extremely handsome piece of work as well.

THE INGALLS BUILDING — THE LARGEST CONCRETE OFFICE BUILDING IN THE WORLD.

Among the earlier large concrete buildings in this country is the Ingalls Building, of Cincinnati, designed for office, banking, and telephone exchange purposes, and undoubtedly the most ambitious structure of this kind up to the time of its construction. It was begun on October 2, 1902, and completed late in the following year. It has sixteen stories, a basement, a sub-basement, and an attic, measures 100 x 50½ feet, and rises to a height of 210 feet from the sidewalk to the cornice. The distance from floor to floor is 12 feet 6 inches for the office stories, and 17 feet in the telegraph exchange on the sixteenth floor. The concrete construction as compared with a similar structural steel design permitted a reduction in height of about one foot for each story, a saving due to the shallower floors. The construction is on the Ransome system, in which the concrete is reinforced by rods, bars, stirrups, and hoops of twisted steel, is solid and continuous throughout, and was essentially completed as the work progressed, the rate at times being one entire story finished every twelve days. The foundations are of the spread type, and rest upon a good stratum of gravel and sand.

The boldness of the structural design, at least for that period in the development of the use of concrete, is well shown by the spacing of the columns, which is such as to require girders of 16 to 33 foot span, and floor panels 16 x 33 feet between the main girders. The columns are 16 to 33 feet apart, center to center, and decrease in size from 34 inches by 38 inches at the basement to 12 inches by 12 inches at the roof. The footings vary in size according to position and loading, and are built independent of the columns. Each has a rectangular pedestal, slightly greater in horizontal dimensions than the column, and upon this is a cast-iron base plate provided with circular projections to form top seats for vertical round steel bars imbedded in each column to add compressive resistance thereto. Each column, according to its size, has four, six, or eight such bars, 2 to 3½ inches in diameter, and the joints of these are formed by faced ends in contact. Besides, each column has four to ten twisted steel bars to resist tensile strains due to wind pressure loads, and rectangular hoops, lapped and tied by wire, to bind the bars at vertical intervals of 12 inches.

As mentioned above, the main girders between columns are of 16 to 33 foot span, and those of the first floor, including floor slabs, have a depth of 36 inches, those of the second floor 34 inches, and all above the latter 27 inches. The width throughout is 20 inches. They are formed monolithic with the walls, columns, and floors, and the extremities of their horizontal steel rods project into the columns between the vertical reinforcing members of the latter. The girders are additionally strengthened by alternately inverted U-bars of twisted steel. The junctions with the columns are reinforced by vertical diagonal twisted bars, from the top of the girder downward, and from the bottom upward into the body of the column, the lower ones being concealed in concrete brackets.

The exterior walls, exclusive of facing, are 8 inches thick, with the exception of those in contact with the walls of adjacent buildings, and these are from 3 to 4 inches thick. All are reinforced by vertical and horizontal twisted steel bars. The exterior facework is of 4½-inch marble for the three lower floors, and above these of glazed bright gray brick with terra-cotta trimmings. The brick facing is supported at each floor by a ledge formed in the concrete, and is also secured by wire anchors projecting from the concrete. The marble facing and the terra-cotta trimmings are provided with grooves in the back, the top and bottom surfaces of which have upward inclinations. These grooves engage with ribs of similar section on the face of the concrete, and thus form a species of dovetail joint. The exterior window and door frames are of cast iron for the first floor, and of sheet iron for the remaining stories. There are four hydraulic elevators running in concrete wells for passenger and freight purposes, and two for use in connection with the floors below the surface level. The space beneath the sidewalk is utilized, and in this connection concrete retaining walls are employed.

For the installation of the concrete steel construction, three stories of interior forms and two stories of exterior forms were used. The method of employing these forms is illustrated in the first of the accompanying engravings. The interior forms of each story were removed in twenty-one days, and were used for the construction of the third story above. The exterior forms were removed in fourteen days, and applied in the construction of the second story above. At the time the photograph was taken the ninth floor, with its beams and girders, and the columns of the story below, had been completed in about twenty-three days, and its interior forms had been raised to be used for the twelfth floor and the eleventh story columns. The exterior forms for this floor had been raised from the tenth floor and the ninth-story columns, which were completed in about fourteen days. As the forms were raised, the portable scaffold, shown at the tenth and eleventh floors, was raised coincidentally with the forms.

At the fifth floor level may be seen the swinging scaffold employed by the general contractor for the brickwork. At the second story is shown the marble facing and its strap-iron anchors projecting from the concrete wall. These anchors, which were used in addition to the dovetailing described above, are placed at joints in the marblework, and each has a small steel pin which passes through a hole in the anchor and is fitted into a recess cut into the marble. The black waterproof paint, seen at the third story, was employed to insure the marble against the possibility of stain from the concrete. This paint was applied at the time when the forms were removed, thus offering a means for a thorough inspection of the surface of the concrete as the building progressed and as the load increased. It is claimed that this paint has since remained in as perfect a condition as when first applied. All the stories up to and including the ninth were in the process of being plastered, and all other branches of the work, such as the installment of the marble-work on the floors, doors, and partitions, the heating, plumbing, and electric work necessary for completely furnishing the interior, were being completed, for each floor formed a perfect roof as soon as concreted.

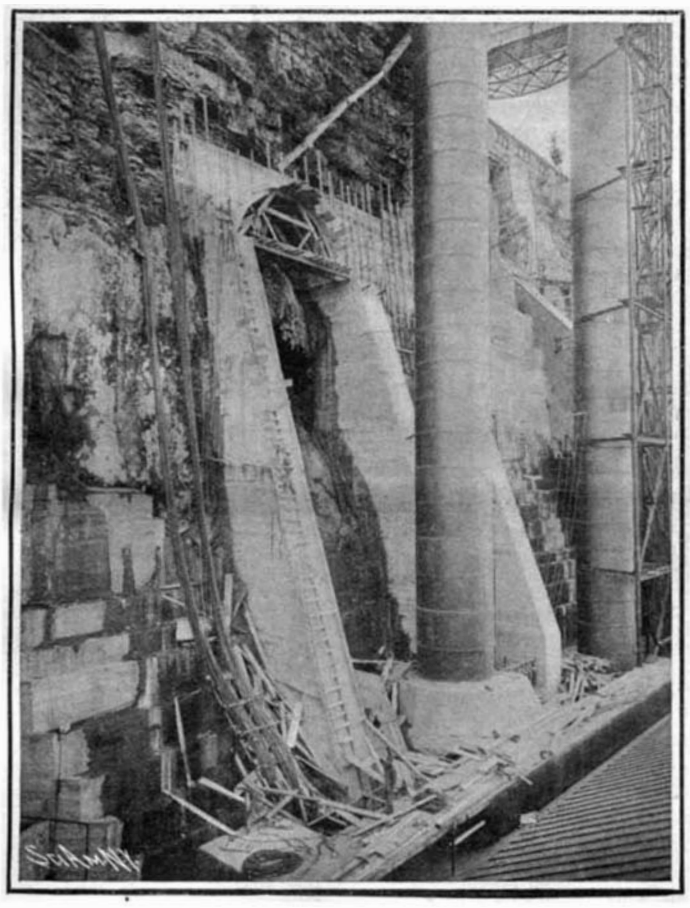
The second photograph is a view of the third floor, showing the beam and girder forms filled with concrete, and the completion of the floor above about to be accomplished. At the extreme left is shown the method of providing round steel bars to furnish compressive resistance that the area of the column may be reduced. The bars are carried to a point from 6 to 18 inches above the floor level, and rest directly on the tops of the bars below, with a joint made with an inclosing pipe sleeve filled with neat cement. At this point also may be seen the method of employing twisted steel uprights, diagonals, and horizontals in the columns and tops of girders at the supports, to resist wind and floor load stresses. In the foreground are shown the twisted steel U-bars used to assist in withstanding longitudinal sheer in the girders.

A GREAT CONCRETE RETAINING WALL.

BY ORRIN E. DUNLAP.

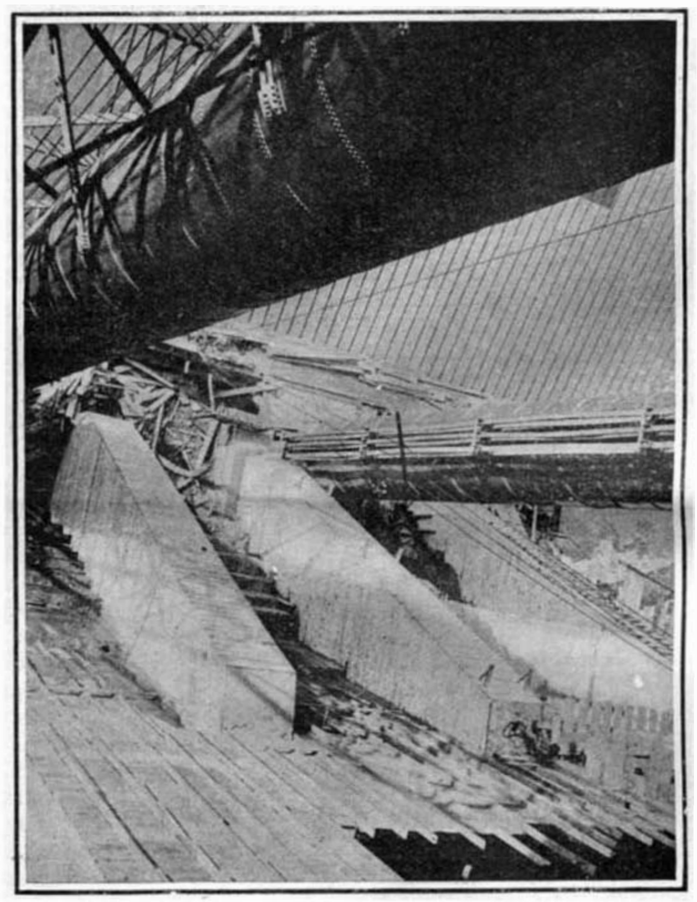
What is believed to be the highest concrete wall in existence has just been completed by the Niagara Falls Hydraulic Power and Manufacturing Company at Niagara Falls. This remarkable work was made necessary by the slow but constant deterioration of the cliff to the rear of the company's power station, which is situated at the water's edge in the gorge, on the New York side of the river below the upper steel arch bridge. At this point the talus or apron of fragments has been cleared away to make room for the power house. The cliff is vertical, the rock being limestone at the top, resting on gray shales, which the rain and frost more or less affect. It is claimed by geologists that the recession of the Falls of Niagara is due to the destruction of the shales, leaving the heavy limestone without the support of the softer rocks beneath, so that from time to time huge blocks break away and fall into the river below. To-day, where it is possible to look under the sheet of falling water of the Falls, the limestone would evidently be without support; that it projects out shelf-like, and no doubt will in time break away. Knowing that this action was taking place at Niagara, the Niagara Falls Hydraulic Power and Manufacturing Company felt that in time the deterioration of the shale back of its power station would injure the strength of the supports of the limestone above, and thus endanger the retaining walls of the forebays, while the possibility of falling rocks was a source of danger to the power house as well as the employes and workmen about the power station at the water's edge. While this prospective danger was unquestionably a very long way off, the realization of its occurring caused the company to take careful steps to avoid it, thus anticipating any likelihood of injury to its employes or power station.

It was these conditions that resulted in Chief Engineer John L. Harper designing the facing wall referred to. He found that the cliff had previously been faced up to the shale, at which time the possibility of extending it to the top was not considered. It was therefore deemed advisable to construct three pilasters to give the upper and heavier parts of the facing wall a more stable support. The wall is made of 1-3-5 concrete filled with a clean rubble. Its length is about 200 feet, and it is not less than two feet thick at any point. The wall drops to the level of the tail water, and extends fully 150 feet above the eaves of the power house, which are 30 feet high, making a facing 200 feet high composed of about 7,000 cubic yards of concrete. The pilasters are 5 feet wide and 80 feet high. In places the wall has a thickness of as much as 12 feet.



The Highest of Concrete Walls.

Character of Cliff Above the Wall.



Bird's Eye View of the Pilasters of the Concrete Wall.

A GREAT CONCRETE RETAINING WALL.