THE CONDITION OF THE STEEL WORK IN A SAN FRANCISCO BUILDING ERECTED 13 YEARS AGO.

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The removal of the upper six stories of the eight-story† Mutual Life Insurance Company building, located at the southeast corner of Sansome and California streets, San Francisco, Cal., offered an unusually favorable opportunity for noting the effect of rust, earthquake and fire on a steel-frame structure that had been standing for thirteen years. This building (Fig. 1) was erected in 1893. It was particularly well designed for those times, and the workmanship was of the highest class throughout. The mortar was not of the best quality, but the workmanship of the brick, stone and terra-cotta laying and the filling of all the joints with mortar was as nearly perfect as possible. The designing was done and the construction superintended by Mr. Clinton Day and Mr. Nathaniel Blaisdell, two well-known architects, who stand in the first rank of their profession in San Francisco.

All walls were self-supporting. They had granite facing in the two lower stories, while the upper six stories were common red clay brick faced with Roman-size yellow brick and with a large amount of ornate yellow terra-cotta, including also a heavy terra-cotta cornice that projected more than 4 ft. The exterior walls were built around a steel frame with bolted connections, which was also self-supporting, and which, together with the interior steel columns carried all the weight of the floors, interior partitions, etc. The floors were made of hollow terra-cotta short-span straight arches, covered with lean cinder concrete, in which the wooden floor screeds were imbedded in the usual manner. The partitions were hollow terra-cotta blocks.

EARTHQUAKE DAMAGE.—The testimony of the janitor and several tenants was that the earthquake did almost no damage to any part of the building. Such damage as occurred was limited to a few small pieces of plastering that fell down. There was no evidence gathered during the taking down of the building that would tend to show that the building was in the least injured structurally by the terrible earthquake.

FIRE DAMAGE.—The effects of the fire were no different than those of Baltimore, Sioux City, Rochester and Toronto, all of which preceded, on a much smaller scale, the fire of San Francisco. The granite in the lower two stories was very badly spalled where the heat came out of the windows, but it was nearly intact where the draft was inward, as around the entrance to the main stairway. The beautiful marble hallway was a wreck from bottom to top. The marble toilet rooms were completely destroyed by heat-expansion cracks, although they contained no combustible material whatever.

FIG. 1. MUTUAL LIFE INSURANCE CO. BUILDING, SANSOME AND CALIFORNIA STS., SAN FRANCISCO, CAL.

Sansome St. Front viewed from Merchants' Exchange on Oct. 28, 1906, during removal of six upper stories for rebuilding. The walls, partitions and most of the floor arches have already been taken down. The wreckage of the intermediate roof-truss over the deep central part of the eighth story has also been removed. A stiff-leg derrick is being set up on the eighth floor, using an old wooden flagstaff as gin-pole.

Common clay red bricks stood the heat better than any other clay material. The yellow Roman-size brick and the yellow ornamental terra-cotta were very unsatisfactory, but stood much better than did the granite or the hollow partition tile blocks.

Both floor blocks and partition blocks showed most conclusively that, while terra-cotta is in itself incombustible, it is a very unsatisfactory material to use in connection with steel, as its coefficient of expansion by heat is so much greater than that of steel that it fails by buckling due to expansion long before it is ruined by fire or by water. Furthermore, those floor arches that

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†The central portion of the top story of this building was twice the height of any other story, and was occupied by the Merchants' Club. The side portions had an intermediate floor between the eighth and the roof, and the building might therefore be rated as nine-story.

apparently were but little injured, were not as sound as they appeared. Some of them sagged, little by little, as much as 4 ins., requiring constant attention while taking down the building; in many cases the laborers slumped through them while walking on the floors. It being so dangerous, it was finally deemed advisable to cover over the first story of the building with planks to the thickness of 18 ins. to prevent possible accident in the Canadian Bank of Commerce, which occupied without interruption the lower story of the building.

FIG. 2. APPEARANCE OF INTERIOR AFTER REMOVAL OF LOOSE RUBBISH.
View at Elevator Shaft, Fifth Floor.

Many kinds of plastering were used throughout the building. None of it stood well. There was no plastering of Portland cement in the building. The Portland cement sidewalk and steps stood exceedingly well.

Although there was but little wood used in the building, yet together with the office furniture and fittings it was sufficient to burn up every combustible thing and to create a draft sufficient to remove all traces of wood ashes. With this interior heat, aided by the intense and lasting heat of the conflagration on the exterior, the walls expanded in various directions, completely shearing some of the bolts of the steel frame. It is known that this shearing was due to the fire and not to the earthquake, for the reason that the shearing is found only at or very near the points of the expansion cracks.

CONDITION OF STEELWORK.—The steel frame furnished the most interesting subject of the entire building. When it was known that the writer had the contract for removing the top six stories of a 13-year-old steel-frame building, we were besieged from all quarters for information. Engineers and architects inquired about the condition of the frame. Paint manufacturers and dealers wrote to find out what kind of paint was used to prevent rusting. Advocates of certain so-called "systems" of fireproofing wanted data regarding steel in contact with cinder concrete.

All plans and specifications of this building were destroyed in the great conflagration, and consequently the original specifications cannot be quoted, but it is reasonably safe to state that the paint used was ordinary red metallic paint. Where this paint was in contact with lime mortar the steel was in very good condition, with little indication of rust. The walls in the top story and above the roof of the building were laid in a mortar containing a larger proportion of Portland cement than that of the lower stories, and under similar conditions there seemed to be less rust where Portland cement and lime were used than where lime alone was used. There was no place observable where mortar with no lime in it was used.

It must be remembered that, as already stated, the joints in the brickwork were exceptionally well filled, and this means that the mortar was generally, in fact almost without exception, well filled around the columns, but there were some instances where the ornamental terra-cotta facings prevented the mason from slushing in the mortar as well as he could around the columns. In one of these cases there was a piece of rust scale larger than a man's hand, and so firm that it would stand handling by one of its corners. This was the very rare exception and the beams it came from would even now stand fairly well in comparison with the average steel beam that has been carried in stock in a steel yard for several months. Figs. 3 to 7 are representative views of the steelwork as it was found during the work of demolition.

There were occasional instances where there was some rust under the paint, probably due to the fact that the steel was not thoroughly cleaned before painting. These cases were comparatively rare, but with these exceptions the rust had not developed in thirteen years beyond a negligible amount, in fact all of the straight columns, beams, tie rods and bolts have been sold for use in new buildings now in progress of erection.

FIG. 3. A COLUMN SPLICE AND THREE FLOOR BEAM CONNECTIONS, SHOWING PRACTICALLY NO RUSTING (CINDER CONCRETE).

The following conclusions the writer believes to be unquestionably correct:

1. A steel frame, properly painted and buried in masonry, will not rust enough in thirteen years to affect its strength any measurable amount.

2. The better the steel is coated with mortar the less it will rust.

3. Portland cement is better than lime mortar for imbedding steel to prevent it from rusting.

4. Unpainted iron rods buried in mortar composed of lime and a large proportion of Portland cement rust very little, certainly not enough to impair their strength.

5. Columns should be of such cross section that they can be thoroughly imbedded in Portland cement, avoiding a hollow column unless latticed and filled with very soft concrete.

6. Wherever possible, preference should be given to those shapes of steel that present the least surface to the action of rust.

7. If steel is not thoroughly cleaned from rust before it is painted, the paint will not greatly retard the progress of the rust.

8. It is much easier to cover steel thoroughly with concrete than with brick masonry. If brick masonry is to be used the bricklayer should thoroughly plaster the steel work ahead of the brick work.

9. The quality of the paint used, though important, is not so important as surrounding every part of the steel with Portland cement.

10. Interior columns do not rust as much as exterior columns.

11. Cinder concrete does not injure to the slightest degree a steel floor beam that has been painted.

12. No pipes or wires should ever be placed behind fireproofing, as they will buckle from the heat and push off the fireproofing.

13. This building probably could have been saved intact if it had had fireproof exterior door and window-frames with wire-glass and an emergency water-tank on the roof.

14. Terra cotta blocks are not as good as concrete for fireproofing interior columns, nor do they protect the steel from rusting as well as does Portland cement concrete.

15. Neither marble nor any of the well-known kinds of plaster will withstand heat. There is a tremendous demand for some durable material that can be worked as easily as can wood or plaster, but that will resist great temperatures.

16. There is no reason to fear structural damage in tall buildings, in San Francisco or anywhere else, by a recurrence of earthquake as severe as that of April 18, 1906, provided these buildings are properly designed and properly constructed, since this building, which was taller than the average ten-story building, and was built on made land, went through the earthquake without a structural blemish.

Fig. 4. A Wall-Column Broken Off by Fall of Roof Truss Over Central Part of Eighth Story; Attachment of Lower Chord of Truss.
No material rusting appears on either column or truss.

Fig. 7. Appearance of a Wall-Column after Removing Masonry.
Floorbeam connections at fifth floor level. The column, floorbeams and details show an excellently preserved surface.

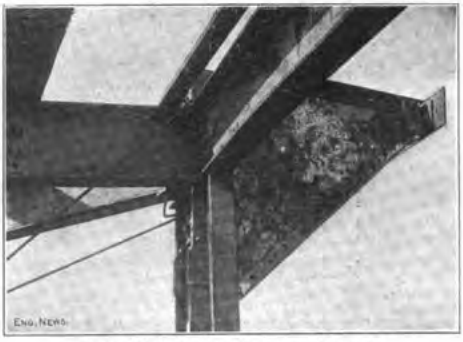

FIG. 5. CORNICE BRACKET AT ROOF LEVEL.
The web-plate and flange-rivets are badly rusted.

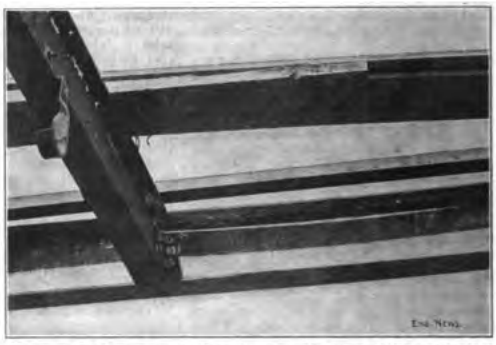

FIG. 6. EXCELLENT PRESERVATION OF BEAM WHICH WAS PARTIALLY BURIED IN CINDER CONCRETE.