SLOW-BURNING CONSTRUCTION.

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MANY of the methods of building now in vogue are very defective with regard to fire-resisting qualities. These methods are retained with a tenacity which indicates a very conservative habit of mind and an unreasoning adherence to traditions of methods of building which are unworthy of this scientific and progressive age.

The prevailing type of building could scarcely be improved upon if we should set ourselves to design a structure which should in the most rapid manner convey fire to every part while at the same time shielding the conflagration from the effects of water thrown upon it from the exterior. Every floor consists of an aggregation of flues connected with other flues between the strapping or alongside of hot air flues, runs for pipes, etc. In very many instances it occurs that a fire, starting in the basement, next shows itself in the attic on account of this method of construction, or by means of unprotected elevator and light shafts.

The method of attachment of the beams and joists to the brickwork is also very defective and illogical. The beams are so securely anchored or tied into the brickwork as to utterly demolish the walls when these burn through and drop. In like manner the joists cause similar destruction of the remaining walls. Frequently, after carefully bevelling off the ends of the joists with the hope of averting this disaster, we deliberately anchor a number of these very joists to the walls so thoroughly as to entirely nullify the good effects of the bevelling. Again, we still have occasion to observe the use of 3" x 4" bond-timbers in walls only 9" to 13" in thickness. Could any method be invented for more surely bringing down a wall than this? This method of building makes a party wall of less thickness than 18" practically useless as a reliable fire stop, while even the latter thickness will, with the construction referred to, permit the passage of smoke and the consequent ruination of goods.

The methods of thoroughly fire proofing buildings are too expensive for the ordinary class of store, factory and mill property. A fire-proof mill is conceded to be a commercial impossibility. The enormous losses in buildings of the warehouse, mill and factory class, constructed in the ordinary way, combined with the heavy premiums exacted by insurance companies, forced the mill owners in the large manufacturing centres of the New England States some years ago to call a halt and endeavor to reform the methods then in vogue. The system of slow-burning construction was gradually evolved through the efforts of Factory Mutual Insurance Companies. As a proof of the success of this system combined with the use of automatic sprinklers, the rate of insurance per annum has been reduced from 2½% to less than ¼ of one per cent. The principle of this system may be briefly described as "the construction of buildings in such a manner as to offer the most efficient means of retarding the spread of fire; the aim being that the limits of destruction shall be reduced to a minimum by making buildings slow-burning, rather than striving to make them fire-proof."

The chief points to be avoided are rafters or joists placed at the usual 16" to 20" centres and set edgewise, (Fig. 5), all hollow spaces in either roofs, floors or wainscot, boxed cornices, open elevators or stairs, iron doors or shutters.

The main points to be observed in safe construction are: Solid beams or their equivalent in planks bolted closely together and spaced 8 to 10 feet centres; ends of timbers ventilated by a proper air space, (Figs. 1 and 2), Fig. 1 being a simple iron plate, and Fig. 2 a cast iron box. Wooden posts of proper size, bored with at least an 1½" core with ½" holes near top and for ventilation (Fig. 3), (a) shows iron pintle and (b) wood post carried to cap of post below. Floor planks of from 3" to 5" thick according to span, finished floor of 1" to 1½" matched stuff with ¾" of mortar between or double thickness of asbestos sheathing paper (Fig. 6). A space of ½" to ¾" should be left between walls and floors to allow for swelling of planks and the gap thus formed may be concealed by a fillet. Roofs nearly flat of at least 2" thickness, beams projecting beyond walls forming brackets for gutters (Fig. 4). Doors where necessary to stop fire of double inch put together diagonally and completely encased with tin locked and tacked, the frames also covered. In many cases these doors should be automatic in action, an alloy fusible at a comparatively low temperature being incorporated with the apparatus holding them open.

The ideal slow-burning mill is but one storey in height, the area being obtained by greater width of building, light reaching the centre by means of skylights or monitors (Fig. 9). When land is expensive or the available space contracted, it becomes necessary to build higher, but always of course with increased fire-risk. The stairways as well as the elevator shaft should be enclosed with solid brick walls (Fig. 7). All belt holes should have raised edges and the doors thresholds to retain water and prevent damage to lower floors.

The saving in height of building where the system is carried out in its simplicity will amount to about 10" in the height of each storey, resulting in less brickwork, less stairs, piping, heating and belting (Fig. 8). The weight of the old style floors and the slow-burning is nearly identical, but if the sheathing of ceilings of the former be omitted the difference is about 10% in favor of the latter.

With solid floors belt holes can be conveniently cut at any place between the beams without the weakening effect so often seen in factories, when frequently the joists have to be cut. It is also claimed that the solid plank floor has less vibration than the hollow one of joists and thin floors. There is also the absence of lurking places for vermin and dust.

The elastic, or cushion property of wood, makes it the most suitable and practicable material for the construction of floors for industrial purposes. Machinery will rack and wear out much sooner on stone or iron, unless cushioned, than on wood.

Southern pine, on account of its qualities of strength, straight grain and elasticity, is the favorite wood for mill beams, but it would be altogether too expensive for use with us. Our white pine of perhaps a little larger scantling, is a very suitable wood.

The strength of wood varies greatly, even in pieces of the same kind and dimensions. Authorities say that it is the elastic limit rather than the breaking strength which should be considered in the case of floors carrying weight, and that continual strain causes what is termed fatigue of the fibres of the wood, causing eventual breakage under loads of less than the instantaneous breaking weight. A load of less than the elastic limit should therefore be provided for, and as this limit is not obtainable with any degree of accuracy, a factor of safety of 6 is recommended for dead loads, and double that for live loads.

Woodbury, in his work on mill construction, gives some very interesting tables of strengths of beams and floors. The following are a few quotations for a storehouse, but not for the support of machinery, the deflection being somewhat more than would in that case be advisable: Beams of southern pine, 8 ft. centres; spruce plank, weight of goods 100 lbs. to the sq. ft. in addition to the weight of material of construction; thickness of floor plank 3.42; span 13.73 ft.; beam 6" x 12"; for a span of 17.23 ft., a 7" x 14" beam; and for a span of 20.96 ft., a beam 8" x 16". For a load of 200 lbs. to the sq. ft., a 12" x 6" beam would be safe for a span of 10.98 ft; a 14" x 7" beam for 13.80 ft; and 16" x 8" for 16.81 ft., with a floor thickness of 4.83 inches. The elastic limit of the deflection of floor beams is said by the same writer to be about one 400th for a span of say 25 ft. or ¾", while the floor plank in a span of 8 ft. should not deflect more than 1-13". (Mr. Woodbury confesses that these limits are empirical and matters of opinion based on experience, and that they have been exceeded with no apparent evil results.)

On account of the increase of the tendency to lateral vibration in proportion to the increase of the height of the building, the width of the floor beams will need to be greater in a building of several stories than in a one-storey structure. The deflection of the planks of a floor have been proved to be less where they cover two than where they cover one span, and the joints should be alternated so that an equal load may be imposed on each beam.

Mr. Woodbury has computed and compiled a very useful table* of distributed loads upon southern pine beams, with limit of deflection. By its use it is a very simple and short process to find the safe load or the required span of floor beams for an assumed load. For example: The safe load per sq. ft. upon a floor with 12" x 14" beams of southern pine 10 ft. centres and 24 ft. span. The table shows that a beam 14" deep of 24 ft. span will sustain 42.37 lbs. per ft. of span for every inch in width of beam. Multiply this by 12 for the width of beam 12 x 42.37=508.44 lbs. per foot of span, and the bays being 10 ft. wide, this corresponds to 508.44÷10=50.84 lbs. per sq. ft. of floor. But the weight of floor must be deducted thus:

Beams.........	5.60 lbs.		
1¼ Flooring..	5. "	Total safe load......	50.84
Mortar........	6.25 "	less weight of floor...	26.85 equals
Plank........	10 "		
		say....	24.00 lbs. per sq. ft.
Total.....	26.85		

or for required span of beams assume the load at 30 lbs. per sq. ft., add weight of floor, say 27 lbs.—gross load 57 lbs—beam 12 x 14, 8 ft. centre. Total load per ft. of beam 57 lbs. × 8=456 lbs., which divided by 12=38 lbs. per inch in width. In the table under 14 the nearest number to 38 is 39.08, which corresponds to or indicates a span of 25 ft.

Wood, as a material for mill columns, has been proved more reliable than unprotected iron in case of fire. Its cost is not great, and defects are easily discovered, which is not the case with cast iron columns. The only recorded tests of full size wood columns are those made at the U. S. arsenal Watertown, Mass., for the Boston Manufacturers' Mutual Insurance Co. Tests of small sized models have been proved entirely unreliable. The average crushing load per square inch was 4,422 lbs. for cylindrical columns 12 ft. in length and 10½ inches diameter. Cylindrical columns represented a resistance 24% greater than a tapered column of the same diameter at base, while the difference was 56% in favoring a square column with the angles merely chamfered an inch. The reduction of strength when the load was slightly eccentric was very marked, showing how necessary it is to insist on careful setting. The crushing resistance of bolsters was found to be very small, showing that they are quite unreliable when heavy weights are to be carried. This would indicate that the use of bolsters or the supporting of posts carrying heavy weights from beams is decidedly inadvisable (Fig. 5).

In concluding this paper, the writer would remark that while the system of slow-burning construction may be suitable for buildings devoted to manufacturing purposes, and in some cases to warehouses, it should not be seized upon as a panacea for the safety and mode of construction of every building. Some enthusiasts have rushed to this conclusion and have found themselves involved in insurmountable difficulties when attempting to bend the system to their purpose. Every building contains its own constructive problems, which should be worked out in a logical manner, and with the invention born of the needs of the occasion.

The people of Salmon Village, Peel County, have had the name of their post office changed to Terra Cotta. This, in the opinion of the Montreal *Gazette*, is being particular to a shade.

* Fire Protection of Mills. P. 159.