The laws controlling buildings appear under very different titles—Acts, Bye-laws, Codes, Ordinances and Regulations, etc. To avoid complexity I will refer to all as regulations.

Some of these are Acts of Parliament, but most are Municipal; the former more slow and difficult to alter than the latter. In some, like Melbourne, the main Act is Parliamentary, but the practical details are in schedules that can be altered to keep abreast of the times.

All deal with the safety of buildings as regards the public outside, and many include the safety of those inside. All seek to check the spread of fire, also to secure proper space for light and air round buildings. Some in the older cities deal with the widths and directions of streets and others deal in detail with drains and wastes and traps and other sewerage matters. One goes so far as to prohibit smoking in workshops and stables.

As to their history, that of London commenced in the reign of Charles II., and was amended in the reigns of Queen Anne, George II. and III.; then several times in that of Queen Victoria, and the last amendment was in 1905. Melbourne is nearly a copy of London, 1844, but the last schedule is dated 1888. Sydney still bears date 1879; Glasgow has been brought up to 1900, and Liverpool to 1902; Manchester also to 1902 has adopted the Local Government Board model bye-laws. Birmingham also adopted these models, but made amendments in the thickness of walls in 1902, as they "found the requirements in operation to be unnecessarily severe, and to increase the cost of building without any corresponding advantage."

All these British regulations are silent as to steel, skeleton or modern construction, and still compel people to load the earth with masses of brickwork, which occupy valuable and expensive space that would be better devoted to goods and persons.

In great contrast are the regulations of New York, 1901; Chicago, 1905; Toronto, 1904; Minneapolis, 1905; San Francisco, 1907 (the latter so recent that the last amendment was not signed by the mayor when the book went to press).

Safety of life is the keynote, rather than the rights of property. They include in their scope much of the work of our factory inspectors and public health inspectors. Except in private residences they deal with stairs and exits and fire escapes and water supply for fire. Some are large and elaborate treatises. Instead of pages about party walls and party structures and adjoining owners and elaborate definitions which include the occupants as well as the owners, we have short, snappy definitions,
and at the most a page of instructions as to neighbours' rights and duties when building, duties which are fulfilled by the authorities at their expense if they delay.

Of all these regulations London, Birmingham, Melbourne and Sydney alone exercise no control over the loading and strength of floors and roofs, although London and Melbourne both enforce ancient regulations as to fire-proofing between tenants of a building who have separate entrances from the street, which fire-proofing is not required if their doors open on to a common entrance from the street, the latter and cheaper plan being infinitely more dangerous in case of fire.

The model bye-laws referred to are issued or approved by the Local Government Board in England, and are being generally adopted by towns in England. The requirements generally are common sense and practical; there is no creating of offences as to party structures, but the regulations as to thickness of walls are in places unscientific and inconsistent, and, as Birmingham found, unnecessarily severe. I will analyse these later on.

Most regulations divide buildings into classes according to the purpose for which they are used, but unfortunately this is not always done in accordance with defined principles. To take an example: The lightest loaded building in the world, viz., the hospital, is treated as a warehouse in England and Canada, and requires to have walls of 4\(\frac{1}{2}\)in. extra thickness in Melbourne, or else to have projecting piers or buttresses, which is worse. In America it is classed with domestic buildings and offices. In America, except in Minneapolis, the shop is classed with warehouses, although a large portion of it may be domestic residence. In Minneapolis they have a special schedule of walls for these mixed buildings.

As the object of building regulations is to secure sufficient strength for safe use, I prepared the following classification for the Melbourne Suburban Buildings Conference, and the sub-committee has adopted it.

**DOMESTIC CLASS.**—Subject to small vibration and light loading of floors, such as residences, residential shops, offices, hotels, hospitals, private schools, club houses, studios, etc.

**WAREHOUSE CLASS.**—Subject to vibration and heavy loading on floors, such as warehouses, factories, mills, and other places for the storage and manufacture of goods.

**PUBLIC BUILDING CLASS.**—In which an assemblage of people is liable to take place, such as theatres, churches, chapels, assembly halls, museums, libraries, and public schools. In this latter class are included the large assembly rooms of hotels and offices; also hospital and school lecture theatres, but not the residential portion of these buildings.

Chicago has eight classes of buildings, all of which have different requirements as to staircases, exits, etc., but the wall tables, when compared, group into these three.

New York and Toronto have these three classes, but in Sao
Francisco there are 12 definitions of buildings of different use and requirements.

Some American regulations are very elaborate. In San Francisco, in addition to the 12 definitions of buildings, there are fire limits (we call them areas); fireproof roofing limits, and mill construction limits. There are five classes of construction: A, B, C, C. Mill, and Timber Frame, all clearly set out so as to allow of buildings being erected as cheaply as fire risks will allow. Toronto and Chicago have also four or five classes of construction, and each has several fire limits or areas.

Associated with the uses or purposes of buildings is limitation of height, and in some places limitations of area and cubical content. These limitations are made in the interests of safety to life and property and the checking of fire.

As in America they are based largely upon the safety of the construction, I will briefly describe the various methods of construction, of which there are four great classes: Fire-proof, Slow-burning or Mill, Ordinary Construction, and Wood Frame.

In the Fireproof Class, there are two divisions. In the first, called "A" in 'Frisco and skeleton elsewhere, there is a steel or iron frame skeleton for walls and floors, and all encased in concrete or other incombustible material. The outside spaces in the skeleton may be filled in with thin brick or stone or concrete walls, each story of which is carried by the skeleton. In 'Frisco, before the earthquake and fire, the height was limited to one and a half times the width of the street in front, but now there is no limit. Toronto limits the height to five times the least width of the building, and Chicago to 260 feet, and Minneapolis to 150 ft.

In the second division, called "B" in 'Frisco and merely called fireproof in New York, Chicago and Minneapolis and Toronto, the outer walls may be brick or stone, but the floor construction must be fireproof as before, and there must be no wood except the flooring and doors and windows. New York does not allow any wood in these buildings if more than 150 ft. in height, unless protected by metal, or rendered fireproof, and all outside frames must be metal. 'Frisco limits the height of this construction to 102 feet and allows re-inforced concrete beams up to that height.

Mill construction varies a little in different places, but generally means no floor to be less than 3 in. thick, no floor beam less than 8 in. square, and no wood post less than 10 in. square. Chicago is a little heavier than these sizes, and Minneapolis is a little lighter. Minneapolis limits the height to eight stories, and Chicago to 100 ft. 'Frisco requires a second thin flooring separated from the thick by waterproof paper, and allows 84 ft. in height. Toronto limits the height to three times the least width of the building. Toronto had another class in which the woodwall is protected with plaster on metal lathing, and there is an extra flooring separated by asbestos paper, and calls the construction "slow burning," but does not grant any concession for its use. The
essence of Mill construction is slow burning, and there are no concealed air spaces. I can find no provision for it in New York.

In Ordinary Construction only the walls and roof covering must be fireproof. All other constructions may be of wood. In 'Frisco there are limits or areas within which the roof construction, as well as the covering, must be fireproof. Such limits should be declared in Melbourne city. 'Frisco limits ordinary construction with wood laths to ceilings, or no laths to 55ft. in height, but allows 84ft. if metal lath be used on all floor and ceiling joists, and girders, studding, wood furring, and soffits of stairs. New York limits ordinary construction to 75 feet, and Chicago to 60ft., and Toronto to 70ft., and Minneapolis to four stories, but the latter allows raising of old buildings, and all of them have lower limits for certain occupations, of which I will give a table later on.

Limits of height are attracting attention all the world over. The increasing darkness of the streets of America in which the light of the many is reduced for the profits of the few; the recent earthquakes and fires; the insufficiency of fire appliances for great heights, and the consequent danger to life and property are arguments against height, and the ideal building would be low, but that would reduce accommodation for goods and habitation, and make rents high and living too expensive, especially to the working classes who have to live in crowded cities. Making the buildings fireproof allows of a higher building without greater risk, but adds somewhat to the cost and rent, and even with fireproof buildings the extra stairs and fire escapes become an expensive item.

The most important element as to height is risk in case of fire, and after that, obstruction to light and air. Uniformity of architectural appearance also claims attention.

The risk in case of fire may be arranged in order of seriousness. First, crowds in theatres, subject to panic; 2nd, crowds in churches, etc., in more serious mood; 3rd, helpless people, but not crowded as in hospitals, asylums, etc.; 4th, people asleep and more or less crowded, as in tenement and apartment houses; 5th, people asleep, not crowded in hotels, lodging houses, etc.; 6th, people awake and crowded and inflammable goods, as in retail stores and factories and workshops; 7th, people awake, not crowded, as in offices; 8th, goods in bulk, as in warehouses.

I have tabulated below the American limits of height for these classes, distinguishing between the various forms of construction, and you will notice that in New York, Minneapolis and Toronto the pockets of the poor are considered by allowing tenement houses a higher limit than hotels and lodging houses, but Chicago does the opposite. In Glasgow concessions are made to workmen's houses. You will notice that Chicago has a low limit for the retail store, and 'Frisco limits it to 102ft., even if fireproof.

In the table stories are indicated by Roman numerals, and are
### TABLE I.

**Limits of Heights of Buildings of Different Forms of Construction According to the Nature of the Occupation.**

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Theatres</td>
<td>All Fire-proof</td>
<td>All Fire-proof</td>
<td>All Fire-proof</td>
<td>All Fire-proof</td>
<td>Fire-proof, exceeding 1000 seats</td>
</tr>
<tr>
<td>2. Churches, etc.</td>
<td>Regulations as to Exits, etc.</td>
<td>Ordinary, to 800 Mill to 1500 seats</td>
<td>Fire-proof, exceeding 300 seats</td>
<td>Fire-proof, exceeding 1000 seats.</td>
<td>Fire-proof, exceeding 1200 seats</td>
</tr>
<tr>
<td>3. Hospitals, etc.</td>
<td>Ordinary, up to 35 ft. high</td>
<td>Ordinary, II.</td>
<td>All Fire-proof</td>
<td>Ordinary, II.</td>
<td>Ordinary, 11.</td>
</tr>
<tr>
<td>4. Tenements, etc.</td>
<td>Ordinary, V.</td>
<td>Fire-proof, VI.</td>
<td>Mill, V.</td>
<td>Ordinary, 11.</td>
<td>Ordinary, IV.</td>
</tr>
<tr>
<td>5. Hotels, Boarding Houses, etc.</td>
<td>Ordinary, 35</td>
<td>Ordinary, III.</td>
<td>Mill, 100</td>
<td>Ordinary, 11.</td>
<td>Ordinary, IV.</td>
</tr>
<tr>
<td>6. Retail</td>
<td>Ordinary, 75</td>
<td>Mill, V. or 60</td>
<td>Ordinary, 95</td>
<td>Ordinary, 11.</td>
<td>Ordinary, IV.</td>
</tr>
<tr>
<td>7. Offices</td>
<td>Ordinary, 75</td>
<td>Ordinary, 100</td>
<td>Mill, 84</td>
<td>Ordinary, 11.</td>
<td>Ordinary, 70</td>
</tr>
<tr>
<td>8. Wholesale</td>
<td>Ordinary, 75</td>
<td>Ordinary V.</td>
<td>Ordinary, 55</td>
<td>Ordinary, 11.</td>
<td>Ordinary, 70</td>
</tr>
<tr>
<td>9. Private Houses</td>
<td>Ordinary, 75</td>
<td>Mill, 100</td>
<td>Mill, 55</td>
<td>Ordinary, 11.</td>
<td>Ordinary, 70</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mill, 84</td>
<td></td>
<td></td>
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</tbody>
</table>

**Note:** Heights are in feet.
counted from above the street level, and heights, indicated by ordinary figures, are also measured from the street level. Generally there is a basement which is not included in the limitation of number. In some cases the ceiling over the basement has to be made fireproof.

Obstruction to Light and Air.—Except with skeleton fireproof structures, 'Frisco limits the height of buildings to one and a half times the width of the street. Glasgow also limits business buildings to the one and a half times, but not more than 100ft., and buildings or tenements to the width of the street. London limit is 80ft., and where the street is under 50ft., the limit is the distance of the new wall from the other side. In both London and Glasgow the Council can allow higher buildings, but owners of buildings within 100 yards can bring objections before the proper tribunal. Both London and Glasgow consider vested interests by allowing re-building to the previous height, and extensions of blocks of the same owner to match existing buildings. Brighton's limit is the width of the street, but the Council can raise it. Liverpool and Manchester, New York, Chicago and Minneapolis have no limits (except Manchester in some very narrow streets.)

In Melbourne the limit of one and a half times would not be felt in the wide streets like Collins-st., but it would be almost fatal to business extension in the narrow streets like Flinders-lane and Little Collins-st., etc. Neither is it necessary. Even with a height limit of three times the width they would be brighter and more airy than London, with its lower limit. Owners in Melbourne have given up land for lanes and rights of way leading from these narrow streets. These largely increase the stock of light and air, and the public have the use of them without payment. Owners should not further be penalised, and the present averages should be increased rather than diminished. There would be little objection to Mr. Mountain's proposed limit of 108ft.

Height Limit for the Sake of Architectural Uniformity is exalted by many who have seen it on the Continent, but is it necessary or justifiable? Should there rather not be some "Board of Taste" to check poor designs, or again, should not owners who build higher than their neighbours be compelled to provide some architectural treatment of the side. We might commence the work of the "higher taste" by prohibiting any advertisements. This, however, is work more for our Institute of Architects than Engineers.

Limitation of Area or Cubic Content are not in America confined to the warehouse class. In the few American towns where there are limits they are governed by the nature of the construction, but English regulations take no note of construction. Liverpool, Birmingham, Manchester, San Francisco, Toronto and Minneapolis impose no limits, but Liverpool requires very heavy walls in warehouses.

New York limits the area of non-fireproof buildings with one street frontage to 8000 square feet, and allows nearly 16,000 where
there are two frontages, and 22,000 where there are three frontages.

As 75ft. in height is allowed to be non-fireproof this gives from 600,000 with one street front to 1,650,000 with three street fronts. For fireproof buildings there is no limit.

Chicago allows 9,000 square feet for non-fireproof and 25,000 square feet for fireproof, but limits the non-fireproof to five stories for warehouses, and allows only 12 stories for goods in the fireproof. Assuming average heights of 13ft. per floor we get a cubical content of 585,000 for non-fireproof, and nearly 4,000,000 for fireproof. London and Glasgow make no allowance for fire-proofing. London’s strict limit is 250,000, and Glasgow is 350,000, but for certain purposes London expands to 450,000 and Glasgow to 750,000, in each case with the special permission of the Council, which can be revoked if the purpose be altered. In 1905 London sought to remove the limitations of 450,000 cubic feet, but Parliament only passed part of the Bill. Glasgow allows old warehouses to be re-built up to 900,000 provided the owners within 18 months registered their rights by filing plans. Melbourne’s limit is 400,000 for buildings, provided the walls are made 4¼in. thicker.

How far municipal authorities should interfere where life is not at stake is a moot point. Cubic content is a matter more for the insurance companies. The points were keenly discussed by the sub-committee of the Melbourne Suburbs Buildings Conference, and 400,000 was unanimously approved as the limit of non-fireproof construction, and unlimited for fireproof. At the same time warehouses and retail shops were restricted to three non-fireproof upper floors. Where there is no cellar this gives a four-storied building. With such a provision seven or eight stories would give sufficient margin of safety for Flinders-lane and other narrow Melbourne streets.

Associated with the uses of a building are the loading of floors and roofs and their strength. As before mentioned London, Birmingham, Melbourne, and Sydney exercise no control as to these matters. Liverpool and Manchester and the Model bye-laws have elaborate lists of the sizes of wood joists, beams, rafters, purlins, etc., but no mention of steel or iron strengths. Glasgow alone of British regulations specifies some safe loads, and I have included them in the following table with the American loads. Glasgow specifies the factors of safety for timber (very high), wrought iron and cast iron, but gives no unit stresses and does not mention steel.

Inasmuch as buildings are rarely loaded to the full extent, some cities—New York and 'Frisco—allow a reduction of the live load in the calculations for beams and columns. For beams 'Frisco calculates 80 per cent. of the load and 60 per cent. for the columns. New York deducts 5 per cent. from the floor load of each story coming down from the top until 50 per cent. is reached, then allows 50 per cent. reduction on all stories down to the bottom. I can
### Table II.

**Maximum Live Loads (in lbs. per square foot) for which Floors, etc., must be calculated.**

<table>
<thead>
<tr>
<th>City</th>
<th>Theatres, Etc.</th>
<th>Churches, Etc.</th>
<th>Hospitals, Etc.</th>
<th>Tenements</th>
<th>Hotels</th>
<th>Retail</th>
<th>Offices</th>
<th>Wholesale Stores</th>
<th>Private Houses</th>
</tr>
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<tbody>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New York</td>
<td>90</td>
<td>90</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>50 or more</td>
<td>50</td>
</tr>
<tr>
<td>Chicago</td>
<td>125</td>
<td>125</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>200 or more</td>
<td>200</td>
</tr>
<tr>
<td>San Francisco</td>
<td>125</td>
<td>125</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>200 or more</td>
<td>200</td>
</tr>
<tr>
<td>Minneapolis</td>
<td>150</td>
<td>150</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Toronto</td>
<td>150</td>
<td>150</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>100 or more</td>
<td>100</td>
</tr>
<tr>
<td>Glasgow</td>
<td>180</td>
<td>180</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100 or more</td>
<td>100</td>
</tr>
<tr>
<td>Montreal</td>
<td>125</td>
<td>125</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>200 or more</td>
<td>200</td>
</tr>
<tr>
<td>M. Enot</td>
<td>150</td>
<td>150</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**Building Regulations.**

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**MINIMUM LIVE LOADS (IN LBS. PER SQUARE FOOT) FOR WHICH FLOORS, ETC., MUST BE CALCULATED.**

- Theatres, Etc., Churches, Etc., Hospitals, Etc.: 90 lbs. per sq. ft.
- Tenements: 60 lbs. per sq. ft.
- Hotels: 60 lbs. per sq. ft.
- Retail: 50 lbs. per sq. ft.
- Offices: 50 lbs. per sq. ft.
- Wholesale Stores: 50 lbs. per sq. ft.
- Private Houses: 50 lbs. per sq. ft.
find no regulation allowing of the reduction in Toronto, Chicago, or Minneapolis, although the text-books quote it as a common American practice. I note the practice here as its adoption in Melbourne might be useful even as a concession in calculating the foundations of buildings proposed to be raised.

Next comes the important question of thickness of walls, associated with which are the height of stories and the length of the walls between return walls or cross walls. Although reinforced concrete is coming along with great strides and the crying need of the day is the amendment of Melbourne regulations to allow its economical use, still the majority of buildings will be built in brick, and some change is wanted to lessen the enormous masses now required in Melbourne, which are the heaviest in the world (except Glasgow and Liverpool warehouses), even heavier than ‘Frisco.

In these days bricks are of better quality than they used to be. We can obtain strong hydraulic limes and cements, but regulations make no concessions for these improvements. One of the signs of progress in a community is not only its new buildings, but the extensions and raising of old buildings. But the raising here is frequently blocked because the old walls are not thick enough to comply with the old-fashioned regulations in force, and although thickening the walls is allowed it involves leaving the building and loss of business. There is no doubt that when the mortar is set and the wall consolidated by age it is stronger, and that there would be no risk in treating such walls as equivalent to thicker walls of new work. The new brick wall in lime mortar depends principally upon the stability of its materials, but it stands all right. The new wall built in cement mortar has an elastic strength as well as stability, and the old wall built in lime mortar has acquired some of that elastic strength. A scientific regulation would recognise this.

In my suggestions to the Royal Victorian Institute of Architects in 1905 I proposed that three stories of brick in cement mortar should be allowed in Melbourne where two stories in lime mortar is now a maximum. Most old walls in lime mortar are entitled to a similar concession.

A scientific regulation would also recognise that increased height in a building exposes it to greater wind pressure and vibration from all causes, and would therefore allow the walls that are near the ground to be thinner than those high up. In every regulation I know, except New York, ‘Frisco and Melbourne there are cases of a greater thickness being required in some low wall near the ground than far up in a higher wall. Chicago and Minneapolis have only one such case; Liverpool and Toronto only two, but in London, Manchester and the model, which are practically similar, there are several.

It looks as if the schedules were prepared without drawing the walls to scale and so comparing the thickness of the upper and middle stories.
The greater the height and the greater the length of a given wall the less its strength. Rondelet gives some examples of how to calculate the proper thickness of a single story, but neither Rondelet nor science help much in the case of walls which are supported or weakened by intermediate floor construction. The problem is indeterminate mathematically, and all we can do is to analyse as scientifically as we can the thicknesses that have stood the test of time. In this experience in the particular locality is most useful, especially when seeking to encourage building by finding a safe minimum. We must remember that every regulation is a restriction of the liberty of the subject, and that restriction should be as light as is consistent with safety. And the problem is to ascertain the minimum thicknesses found to be safe and then to work out a scientific average wall which will avoid extremes of lightness at the top where it is exposed to wind and vibration; also extremes of heaviness at the bottom, where thickness is not required for stability, and only occupies valuable space and increases the pressure on the foundation.

Diagram I. shows a comparison of eight domestic walls, Toronto, the lightest, on top, and 'Frisco and London, the heaviest, at the bottom. These are plotted to an exaggerated scale of thickness, the inner vertical lines being half bricks. Note the extraordinary and unnecessary strengthening of London at the second floor below the top, and the unnecessary thickness of 'Frisco at the bottom. The eighth on the list marked "Suburbs" is the standard wall recommended by me and adopted by the sub-committee of the Suburban Conference, of which a description later on.

Diagram II. shows a similar comparison of eight warehouse walls, Melbourne and London being the heaviest and the suburban a scientific average.

It is interesting to note the peculiar local practice of earthquake-shaken 'Frisco, which enforces the same thickness for residence and warehouse walls. These should certainly show maxima not required in Melbourne, but some warehouses under present Melbourne regulations have been compelled to have some walls thicker than required in 'Frisco, also some London domestic buildings.

In comparing the tables and schedules of thicknesses there is a difficulty owing to the different modes of measurement, etc. In old English Acts the thicknesses were varied according to the floor area and height of domestic buildings, and according to the cubical contents and heights of the warehouse class. Melbourne, alone in the world, still does this. Chicago, Toronto, 'Frisco, and Minneapolis specify the thickness in tabular form for each story. Chicago does not state any limits of height of stories; Toronto and Minneapolis are liberal, allowing from 18ft. clear in the lower story to 14ft. clear higher up, but 'Frisco has the lower limit of 13ft. floor to floor higher up. In New York the off-sets are specified at certain heights measured from the bottom, but
when the off-set does not correspond with the floor level it is made at the nearest floor level whether above or below, subject to one condition, viz., that there shall not be more than 50ft. height of any one thickness of wall. These American and Canadian methods give very uniform walls.

In England the thickness of the bottom walls of domestic buildings is specified according to the total height from the footing, and the reductions in thickness are made dependent upon the number of stories from the bottom, so that a building of several low stories would have a very different wall to one of a few high stories, although their total heights might be equal. One would have some too thin walls near the top and the other some too thick walls near the top.

London and the Model.—Domestic walls are designed for the London type of house with low basement and attic walls and higher stories between, but all averaging 10ft. to the story. Even with an 11ft. average anomalies commence in the higher walls, but with 12ft. to 13ft. stories, as we have in Melbourne, we find the anomalies of three thin stories being allowed on top of the 50ft. and 60ft. walls, and only two similar stories on the 40ft. Also the 9in. break in the second story from the top already alluded to. These are shown in Diagram III., in which the higher walls are of the longer class and the lower of the shorter class.

This difficulty has evidently been felt, for in 1905 London sought to make its schedules more workable by proposing to measure the height of a story from floor to ceiling instead of from ceiling to ceiling, but that portion of the Bill did not pass.

The English warehouse system of walls (Liverpool excepted) allows the same thickness for the top story whether the height be 30ft. or 120ft., and makes no alteration whatever the length may be, although the same schedule in some lower stories makes a difference between a wall of 33ft. long and one of 45ft. long.

It specifies a thickness at the top of the footing dependent upon the height of the wall, and draws sloping lines from this thickness to the bottom of the top story wall and the vertical lines of the walls must not come within these sloping lines, which vary in slope. This extraordinary way of specifying the thickness makes the 80ft. wall average the lightest and the 50ft. wall the heaviest. I sincerely hope it will not be adopted in Melbourne.

To compare the thickness of walls of different regulations specified upon such different principles it was necessary to assume some average heights of stories before plotting the walls in parallel columns for comparison. Studying the various Acts I adopted 12ft. to 13ft. as an average of all. This allows the ground floor about 15ft., and inasmuch as the basement was not likely to be more than 10ft. the saving on the basement would compensate for the extra height of the ground floor.

As to Lengths of Wall unsupported by return and cross walls there are grave differences, and the different regulations appear
inconsistent, and some even petty. In the 30ft. high warehouse class of London there is \( \frac{4}{3} \) difference in thickness between the base of a wall under 35ft. long and one under 45ft. long, and in the 40ft. class there is a similar difference between 30ft. and 45ft. In domestic buildings, Liverpool makes differences for 15ft., 30ft., 60ft., and over 60ft. lengths, the lowest figure being evidently a concession to poorer people. In Chicago there is no limit to the length, but a reduction is made in warehouse walls under 100ft. long. In New York extra thickness, or proper piers are required for lengths over 105ft. Toronto has limits of 75ft. for party walls and 150ft. for warehouse walls. Minneapolis requires extra thickness for warehouse walls over 150ft. long, and allows only two instead of three thin top stories where the length exceeds 60ft., which is a scientific method of grading wall proposed by me independently. Liverpool also has a 60ft. length, but London, Manchester, and the Model have the extraordinary low limit of 45ft. without thickening or piers, a limit for which I can see no practical or scientific justification. Seeing that our Melbourne sub-divisions of lands are based upon the chain of 66ft., I recommended a 60ft. and 33ft. classification to the sub-committee of the Melbourne Suburbs Conference, and they adopted it.

Bases of Scientific Regulations.—When one considers the outside forces acting on a building, and watches the effect of a fire, it becomes evident that the top floor which carries only a light weight, viz., the roof, is exposed to the greatest danger of failure. The stability of the lower walls is increased by the weight of the upper, and failure of the lower walls practically never occurs. Such being the case, the most rational system of scheduling, and certainly the most convenient is to start from the top and work downwards. This is the best feature of the Melbourne regulations, and its adoption for New York would remove its one anomaly, viz., that sometimes the middle of the height of a lower wall is heavier than the middle of the height of a higher wall. Other American regulations are free from this anomaly.

Proceeding to plot out walls according to American and English regulations, I have found that sometimes five, and sometimes six stories were allowed, of two successive thicknesses in the higher buildings. Averaging, these give 2\( \frac{1}{2} \) stories to each thickness. Further, I found that projecting piers were accepted, even in conservative English regulations, as equivalent to extra thicknesses, and so I sketched out what I consider is a standard wall, in which there were three stories of each thickness; but the lowest of each three was strengthened by the addition of 4\( \frac{1}{4} \)in. projecting piers, the width of the piers being \( \frac{1}{4} \) of the length of the wall. Such a wall embodied English and American features. Sketching it out 15 stories high, I found the extreme top gave me the lightest of English and American walls, and the extreme bottom, practically the New York warehouse standard for eight stories. This bottom was heavier than Chicago and lighter than
London. Being of opinion that Chicago was heavy enough, I cut off one bottom story, leaving 14, the bottom eight of which represented the heaviest construction recommended for warehouses, and the top two the lightest allowed for dwellings. This top story of this heaviest construction was labelled extra first grade, and the lightest story, 6th grade, and the intermediate 5th and 4th, etc.

As previously mentioned, it was decided to class walls in lengths of under 33ft., under 66ft., and over 66ft. This was retained for the domestic class, but for warehouses it was simplified to two classes, viz., under and over 66ft. Taking into account the effect of wind and vibration on the higher buildings, it was decided to have three classes of heights, viz., under 28ft., under 56ft. and over 56ft. The word height in this connection means the height measured from the footpath or ground level, as in America, not the English definition, which measures from the footing, and includes the basement walls, which are not exposed to windage. Limits of heights of stories were arranged on lines more liberal than English and stronger than American, 18 times the thickness being allowed in domestic and 16 times in warehouse. Walls with projecting piers were allowed to have heights 20 times and 18 times the wall thickness, respectively. Two stories of gin. wall, were limited to 27ft. for domestic, and 25ft. for warehouse, and three stories of 14in. wall, limited to 48ft. and 45ft. respectively. Three stories of thicker walls were limited to 54ft. and 48ft., respectively. Where projecting piers are objected to, as in hospitals, the walls are allowed to be built flush, but are not penalised with greater thickness below.

I proposed that for walls built in cement mortar, two grades lighter should be allowed, but only one was agreed to. At that time I had not seen 'Frisco or Minneapolis. Since seeing them I should like to re-open the question. It was agreed that sound old walls, approved by the surveyor, should be treated as if built in cement and allowed to be raised, provided that the new walls be built in cement. Here, again, I think two grades lower should be allowed.

Two things are desirable when adopting walls of minimum thickness:—Firstly, regulation of openings, and secondly, provision of steel bond. As to regulation of openings, I suggest that where the openings exceed half the area of the wall of a story, the wall should be made thicker, so as to leave solid brickwork equal to such half, or built in cement mortar, in which case the proportion of solid brick-work need not exceed one quarter, such regulation, of course, not to apply to shop fronts or show windows, whose construction is approved by the surveyor. Steel bond should be provided at the top of walls built in cement, to assist the brick-work when contracting after heat, also on the top of walls proposed to be raised. Most experienced architects do this.

Where walls proposed to be raised are doubtful, they can be efficiently and cheaply strengthened by bolting to the inside of
them, heavy steel channels under the girders. These form pilasters, which can be architecturally decorated, if required. I have done this frequently and saved re-building of brick-work.

MODERN METHODS OF BUILDING.—Such as a skeleton framing and reinforced concrete. One of the principal objects in using these is to save the space that brick walls involve, and secure fireproof construction. Every fire and earthquake in the world increases their reputation, but they are only safe in experienced hands. The comparative cheapness and the saving of land will allow of extra fees being paid, as they should, for checking the calculations and for continuous inspection, but conservative regulations stand in the way. It is needless for me to say anything about this construction, which was recently so ably dealt with by Major Monash, of your Institute. There is a provision in the London Act to allow of walls, if built of materials other than brick or stone to be of similar thickness to that specified for brick or stone, or of such thickness as may be approved by the Council. This probably covers skeleton and reinforced concrete, but they are not mentioned. Sydney, 1879, allows of much less thickness as the City of Sydney Improvement Board may allow, but limits the concession to dwelling houses.

Melbourne gives the referees and Surveyor full powers as to modern methods in regard to floors and ceilings, but is silent as to walls. It is to be hoped that full powers as to modern construction for walls and all other parts of the structure will be given in the new regulations, so that future developments will not have to wait for another amendment of the regulations.

Fire-proof Separation between rooms of tenants, who have separate stairs or entrances, causes much friction in Melbourne. London and Melbourne alone in the world provide for it. It is, I believe, a survival of the ancient idea that every man’s home is his castle, and the separate entrance means a separate castle, which must be separated by fire-proof walls, floors, etc. The acme of absurdity was reached lately in this Institute building, when the chemists below wanted their doors to be moved to the street line (about four feet from its present position). Melbourne regulations prevented this, unless they built a thick brick wall in place of the plate glass windows, which, needless to say, was not done. In these days, dozens of offices in different occupations are to be found in one building, and fires are practically unknown.

London, in 1855, regulated that in every building exceeding 3,600 square feet in area, and containing separate sets of offices and chambers, the floors and divisions should be fireproof. In 1894 it reduced the area to 2,500 square feet, and added that in every building exceeding 1,000 square feet, any part used for trade should be separated from the dwelling parts by walls and floors constructed of fire resisting material. No such provision exists anywhere else in the world, and London in 1905, sought to rescind the regulation absolutely, but Parliament failed to
pass it. But they did pass clauses allowing 3 inches in thickness of terra cotta brick walls or concrete to be used for internal partitions, enclosing stairs and passages, instead of the old brick walls.

Where crowds sleep in the building, some provision is necessary. All American regulations provide for fire-proof enclosures of stairs of tenement houses, and some include the main corridors leading thereto. Some very properly, like Toronto, insist upon incombustible divisions being erected between each tenement, eight rooms being taken as a tenement, but none insist upon fire-proof floors to the passage or rooms of the tenements, which restriction London still has to apply to office buildings exceeding 2,500 square feet in area. It is to be hoped that Melbourne will not follow London, and that it will drop the ancient separate entrance regulation.

Regulation as to Stairs and Fire Escapes forms a large portion of American regulations, which I have not yet tabulated, but I may give an example. At the bottom story of a fire-proof 16-story retail Chicago shop, of 25,000 square feet area six stairways of 30ft. total width are required if the stairways are open, but if enclosed by fire-proof walls, only three are required. Should you feel interested, I shall be glad to give further particulars. Outside fire escapes, so necessary in wooden buildings, in New Zealand, are now compulsory in all brick hotels and lodging houses which are not fire-proof and absolutely deface some of the streets. It is again to be hoped that Melbourne will not suffer in this way.

Hollow Walls are a debatable subject as regards strength, but undoubtedly desirable, if not necessary for health. The Suburban Sub-Committee adopted the regulation that no hollow wall shall be greater in superficial extent in any one story than 200 square feet, unless strengthened by a cross wall or fireplace, of projecting pier in each such area to the satisfaction of the Surveyor.

Fireproof Shutters used to be required in America to all side and back windows of non-dwelling class building above a certain height, except upon the street frontage. Wired glass ¼-inch thick, in metal frames is superseding this, and in 'Frisco, rolling corrugated shutters are allowed, but they must not be locked, except on the first story.

Foundations, according to American regulations, would be a large paper in itself. They specify the bearing power of the soil and the safe crushing resistance of each material liable to be used. Best of all, they control the operations where a neighbouring wall is endangered by excavation and do the work at the expense of the person liable if he delays.

Melbourne has an old-fashioned clause that compels the footing to be underground, and so prevents the use of deep reinforced concrete footings, which are so useful on bad ground.

English Regulations allow and specify a projection of the footings on to the neighbour's land, unless his adjoining wall
interferes, in which case it can be omitted. The reduced width of footing will probably throw some weight on to the neighbour's wall, not by any means a scientific or fair arrangement.

If the adjoining wall has a projecting footing, and its owner fails to cut it off, Glasgow regulations authorise the builder to cut it off, and charge the extra cost to the adjoining owner.

Surfaces under floors.—In the Suburban regulations, it is proposed to compel the removal of grass and soil to a depth of 6 inches from the surface within all foundation walls of brick or stone or concrete, and where required by the Surveyor, these surfaces must be concreted or tar paved. This will tend to stop the bleached, rotten smelling grass, one sometimes finds under modern suburban villas, and which so lowers the vitality of the occupants.

Space for Light and Air round Buildings.—The English regulations as to this are some of them very complicated. The American generally allows only a certain percentage of the site to be built up, but allows the open space to commence some stories above the ground. The Suburban Sub-Committee have approved its commencing at some approved floor level of the building. I propose to tabulate this and other matters for a future paper, if you feel interested.

ADDENDUM.

As to Public Buildings.—London, in 1844, made a regulation that the walls should be 4\(\frac{1}{2}\) in. thicker than domestic or warehouse walls, and Melbourne copied it in 1849, and has not advanced since then, but the official referees give all the assistance they legally can to mitigate this ancient encumbrance. London abandoned the regulation in 1855, and left the walls and construction of public buildings to the discretion of the district surveyors, subject to appeal to the Metropolitan Council. This was repeated in 1894, but the Tribunal of Appeal was substituted for the Council.

The Model includes public buildings in the warehouse class, which is not objectionable where they are of several stories, but leads to difficulties where buildings are on one high story and of considerable width, like a church or theatre.

New York, like the Model, includes them in the warehouse class, but gives the commissioner power to require such piers or buttresses or iron or steel columns as he considers necessary. Chicago and Toronto are very similar to each other, and make the wall thicknesses dependent upon the height and width of the building, further increasing the thickness where walls are over 100 ft. in length. They both give an alternative construction of piers with thin curtain walls, but neither of them deals with the church type of nave and aisle.
Diagram IV.

London Building Act 1898.
The proposed Melbourne Suburban Regulations are very complete in this respect, dealing with all three types of public building, and allowing concessions as to height and span where the walls are built in cement mortar.

In framing regulations for securing safety there is always a danger of the official mind avoiding responsibility by making requirements too severe, especially after times of panic. 'Frisco now requires all hospitals to be fireproof, while other American cities allow from two and four stories of non-fireproof, the average being over three. To require all hospitals in Melbourne, public and private, to be fireproof would greatly lessen official responsibility, but it would be an unnecessary tax on public and private enterprise, especially as most practical men regard three stories as a safe limit when associated with stairs as required by the health authorities. London's over-severity as to fireproofing office buildings and chambers must have involved great expense and rise of rents since 1855, all now practically acknowledged to be unnecessary.

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DISCUSSION.

Mr. Henderson illustrated several points in connection with his paper by reference to diagrams and tables exhibited, and said that if desired he could extend the information to the question of "curtain" walls.

Mr. J. A. Smith pointed out that that was one of the matters with which the Special Committee of the Institute appointed to consider the engineering section of the proposed Building Regulations was already dealing.

The President said the matter was undoubtedly one of great public importance. It was a pity the efforts of builders should be hampered by antiquated regulations. Public opinion seemed to be moving in the matter, and Mr. Henderson had taken an active interest in it by getting together and compiling and comparing the regulations of the most advanced cities of the world. In this he was doing a most useful work. The hour was late, and there was an immense amount of matter to be discussed. Therefore he did not see that they could do much with it then, but when the paper was printed they could all read it carefully and critically and study it. It was desirable that engineers should have some knowledge as to what was recognised as safe structure in connection with the thickness of walls, flooring, etc. As to the pressure of walls and roofs he would like to have something to say later on himself. They did not want to run any serious risk, and on the other hand they did not want to cause the man who wanted to put up a good building to waste his money by erecting walls of unnecessary thickness. He heard some time ago that the total waste
of space in Collins street in this way amounted to a whole block of the city. That was a very important matter, as the land was extremely valuable. At one of the American universities some time ago they made a very careful set of experiments, and found that in the case of some public buildings the floor pressure amounted to 180lbs. per foot. That seemed a large figure, but he fully believed he was in a crowd of at least 180lbs. per foot floor pressure on one occasion at a Manchester theatre. He did not think any discussion could take place then, but when the paper was in print they would find a great many points of value and importance.

Mr R. O. Thompson said that in dealing with high buildings, the paper had made no mention of the pressure of water available in case of fire. The brigade claimed 90 feet as the highest they could go. It was absolutely necessary that power for greater height should be provided for. With valuable buildings in the district between Bourke Street and the Yarra, a special pipe for fire purposes should be laid and connected to engines and pumps at the side of the river.

In Philadelphia there was a splendid service of this description, the pumps being driven by gas engines, available at a moment’s notice, at a minimum cost for attendance; the river providing an unlimited supply of water. They would probably have higher buildings in the near future in the limited area referred to at the rate the city was progressing. The great danger to premises adjacent to the building on fire, principally arose from burning materials on the upper floors, scattered by the wind over the roofs, and entering through the windows of neighbouring buildings. On the occasion of the fire at Craig, Williamson’s, in Elizabeth Street, seven years ago, the light fabrics, and other burning materials were carried as far as the Cathedral, past Swanston Street, with disastrous results to the intervening premises. In his opinion a paper dealing with the stability of the walls of high buildings was scarcely complete without passing reference to fire resisting properties, and the need of efficient extinguishing appliances for the higher floors.

The President said it was an important point, but a good deal had been included in the paper as to the limitation of the height of structures, which probably embraced provision in case of fire.

Further discussion postponed.
had not, in the case of the Murray mouth, as in the case of the Gippsland Lakes, made any allowance for tidal scour which might be created by opening the lakes to the sea. He did not anticipate what actually occurred at the Gippsland Lakes, and similarly he did not anticipate at the Murray mouth something that they might now reasonably expect. As a matter of fact, however, he did suggest certain minor draining at the Murray mouth, his idea being to open the mouth to such an extent that the river steamers might in fine weather pass out from the mouth and over to Victor harbour.

At their last meeting he had pointed out that to utilise Victor harbour for heavy traffic it would be necessary to largely extend the existing works. Sir John Coode had reported on the question of improving the Victor harbour, but the present breakwater was simply one-third the length which Sir John Coode had suggested. He recognised that if Victor harbour was to be utilised the breakwater must be extended so as to include a considerable area.

The President's proposal as to a low grade railway from Melbourne to the Upper Riverina was a very interesting one, but he had not at the present time an opportunity of going into that matter as fully as he would like. It certainly was one that should be very carefully considered.

In conclusion, he would like to point out, as he had done before, that he had not laid his paper before them as an exhaustive report on the Murray mouth, saying that these works should be carried out; but he considered it a project worthy of investigation. The whole matter should be thoroughly investigated, and the views he had placed before them he did not think had been brought forward before. They might prove after thorough investigation to be fallacious; but, on the other hand, he thought they would be found to be satisfactory. The whole problem was one of such enormous importance that it should be investigated.

BUILDING REGULATIONS.

Major H. V. Champion said Mr. Henderson was to be congratulated on having placed before the Institute a great deal of most important information at a very opportune time. As they were all aware, the building regulations had for some time been under review by officers of the City Council. He had expected to have heard the City Architect at that meeting, but he understood that owing to another important engagement he was unable to be present. However, there was a great deal of information in the paper which required to be carefully studied. He hoped there would be a very full discussion of the subject, and at a later stage, if he had an opportunity of going more fully into the matter, he would be able to make some observations upon it.

Mr. John Little, Hon. Secretary of the R.V.I.A. (who was present by invitation), stated that the first word he had to say was
that the building regulations which were at present in operation in Melbourne were quite obsolete; so much so, that it was of no use attempting to reform them, and anything they did in connection with the future must be based on new lines altogether. The paper Mr. Henderson had read was so full of information that probably they would be able to refer to only two or three aspects of a very important subject. Mr. Henderson had evidently made a selection from the regulations of many of the largest British-speaking cities of the world, and had carefully tabulated the results. The comparative tables he had given showed that even amongst experts there existed a very great variation in practice. But he thought Mr. Henderson was on the right lines when he took those varied results, and putting them into the melting pot, brought out something which perhaps was a compromise of many of their conditions, but which would suit our requirements. Melbourne's existing regulations were now absolutely obsolete. They must realise that if Melbourne was to be a city of importance in building matters, they must revise their methods of construction. Reinforced structures, as the paper stated, had stood the test of time, and the various methods of reinforced construction had come to stay. The waste of good space on the ground floor of Melbourne buildings erected under the old regulations was appalling. If they looked at Mr. Henderson's comparative tables, they found that Melbourne had almost the thickest walls of any city in the world. Concerning London (where the walls were thicker still) they had to realise that conservative methods of construction had had their stronghold there for many years.

Where walls were built in cement, undoubtedly some concessions should be made concerning the thickness. It seemed absurd to use a material like cement and yet to have to put the amount of material into such walls as was required when certain classes of lime were used. One shuddered to think of the number of buildings erected many years ago in which rich or fat lime was used, when they were told in the text-books that if they pierced walls the mortar of which was made from such lime to a depth of even one-eighth of an inch, they found nothing but a mass of pulverised lime. Yet these walls stood, and might stand quite as long as walls built with lime having greater hydraulicity. If the buildings in which rich or fat lime was used in the mortar were sufficiently strong, surely if cement were used the walls might be built considerably thinner.

Concerning the 400,000 cubic feet regulation at which capacity their buildings must be fireproofed by a vertical wall, a horizontal division as a fireproof floor would answer exactly the same purpose, and be more effective. There was no commonsense whatever in fixing a vertical division and at the same time ignoring the horizontal division, because a flame of fire generally ascended rather than spread itself in a lateral direction.

He thought they should ask that a schedule of the practice of the main cities of the world be drawn up and accepted by the Insti-
DISCUSSION—BUILDING REGULATIONS.

Mr. Jas. Alex. Smith said the matter with which the paper dealt in detail was more particularly the question of brick walls. Mr. Henderson had shown graphically and by tables the difference between various designs of walls sanctioned in different cities. But it was a question if discrepancy in dimensions meant imperfect designing. The walls differed considerably, but there was the question of material and the question of condition. Take for instance Toronto, given in the paper. There were extreme frosts there; we had none here. Those frosts might occur while the wall was in course of construction or green. The question of the local material used had also to be considered. It was possible that some go-ahead communities might stress a building much higher than more conservative localities; thus personal equation and the question of commercial or race environment were introduced. Regularity of abstract design in this connection might mean an actual imperfection if carefully studied in the light of the varying requirements; the paper did not claim to give that information, which had probably never been published. But in its absence it was somewhat difficult to arrive at a conclusion as to what was just in design and what was not. One thing could be said, however, and that was that the British and foreign designs embodied the best advice available at the respective localities when the regulations were drafted. In his paper the author had stated that the problem was mathematically indeterminate. If that were accepted as a general proposition, then the regulations became simply a question of empirical experience and authority. That was not wholly satisfactory to the engineering mind. Mr. Henderson had looked at the matter with the eye of an expert of great experience and had submitted modifications which he considered suitable for local requirements.

One point in connection with Mr. Henderson's designs had struck him. If he interpreted the diagram correctly, for certain types of building and certain lengths of wall, the height of the walls appeared to be the quantity that determined the thickness. But there might be eight or ten or eleven stories, alternatively, to a given height. With the greater number of stories there might be greater loading; certainly there would be more transverse tying of the structure. He did not find this alluded to.

The author had explicitly stated that he had not dealt with the question of foundations, as that subject would in itself suffice.
for a paper, but it was a question whether the problem of wall design, involving matters of reduction of thickness, could be considered apart from the correlated question of foundation.

Take the case of walls built up to the boundary of an allotment; then the footings would be wholly upon one side, and unsymmetrical with regard to the wall. If on rock this might be of little importance, but if the foundation yielded under compression before consolidation, then the pressure would come first on the "heel" of the footings and in transmission to the "toe" would introduce bending stresses in the type of walls under consideration, more pronounced as the thickness was reduced.

Major J. Monash joined with the other speakers in commending the paper which had been read. It would always be a useful compendium of the information and statistics available on the subject. He thought the discussion should not be allowed to pass without emphasising the skill which Mr. Henderson had displayed in compiling diagram 4 of the walls as proposed to be adopted by the Suburban Amended Regulations. He did not think any internal anomalies in the scheme could be found. Mr. Henderson had proceeded on the basis of constructing the minimum and the maximum wall, and everything between these limits fell regularly into its place. The wall design thus gave a regulated basis and an intelligent method of development. His (the speaker's) views on the brick wall question were pretty well known, and he could hardly address himself to that subject without allowing his prejudices to creep in. Many of the difficulties such as Mr. Smith had alluded to in connection with foundations arose from the fact that it was customary in the past to erect huge cumbersome walls necessary only in small part for carrying the building and in still smaller degree for keeping the weather out. The brick wall necessarily had to be made of considerable thickness to accomplish its own independent stability. As far as the function of the wall for carrying weight was concerned, no usual amount of loading in any ordinary building would ever give any serious stress on its walls. The worst loading in a city warehouse would give to the wall a mere fraction of the permissible stress in compression that the wall could carry, and therefore the wall did not have to be regulated by the vertical load it had to carry. It had, in fact, to be designed to secure its own stability and nothing else. That of course opened up the whole question of the modern system of framed buildings, with wall columns, filled with curtain wall panels of sufficient thickness only to give rigidity against wind and other lateral pressures. It was, however, to be admitted that for a time to come the brick wall would be with them, and therefore it would be necessary to review their position in regard to brick walls, and see if they could not introduce some order, rhyme and rhythm in regard to their design. Alluding to one other point only, the question of the limitation of cubic contents, he was heartily at one with what Mr. Little had said. What could be more effective in subdividing a large building than the hori-
zontal fire-break? Even fire insurance regulations admitted that
the minimum thickness for fire-proof floors need be much less
than the minimum thickness for walls. In London it was five
inches for floors and eight inches for walls. One would think
it should be the other way about. But it seemed to be an in-
grained idea among laymen that floors were much less effective
as fire-breaks than walls. His opinion was the direct opposite.

Mr. J. A. B. Koch (Past President of the Royal Victorian
Institute of Architects) said the preparation of the paper and
the collection of statistics must have cost Mr. Henderson a large
amount of labour, which should be especially useful to the munic-
ipalities in respect to the particulars of the building regula-
tions of other countries. It was a difficult matter to discuss or
criticise. The paper gave an amount of information which would
be useful especially in connection with difficult buildings for Mel-
bourne and suburbs.

The time must come when they would not be required to con-
form to the extraordinary regulations concerning walls which
they had here at the present time. Provision should be made to
sanction horizontal fire-breaks in the form of fire-proof floors
in warehouses in order that fires, which at the present time
ascended from floor to floor vertically in a very short space of
time, might be checked.

The President said the question of having horizontal fire-
breaks as against vertical seemed to have a great deal in it. At
present the floors were inflammable, and a fire went without oppo-
sition right up through the building. Some of the illustrations of
the San Francisco fire showed instances of the use of horizontal
fire-breaks, in which buildings were completely burned out at
the top, whilst the lower part was apparently uninjured. And
in many cases the lower floors were subjected to the falling of
heavy bodies from great heights, and still they stood.

As to the walls, he was full of admiration for Mr. Henderson’s
arrangement. It was consistent and reasonable throughout.
They could take advantage of a wall being short, or cut up into
short lengths by cross walls; also in increasing the thickness of
high walls where wind pressure was great. They could not
calculate the exact stress for all kinds of buildings, but as an
extremely consistent and reasonable and scientific system, he
thought Mr. Henderson’s arrangement could not be improved
upon. The question of the thickness of walls, and what the walls
of the future would be, was a matter of great importance and
interest. One thing he had often looked at, which he thought
might form a subject of some discussion. He saw large and thick
walls set on very thin columns. The bottom story of the building
was required to be nearly all of glass for show purposes. In
most streets the front was of glass and in some cases even the
front and two sides might be of glass, and the higher walls
were then placed upon columns of very small dimensions, and
insignificant lateral stability.
The question of the strength of floors was given in table 2. This was a point in which he was specially interested. In the table the pressure per square foot was given, but the factors of safety were not given. The one without the other was useless.

With reference to the weight on floors, he was positive that in crowded passages and porches there were pressures of at least 130 lbs. per square foot. He had found by experiment a pressure of 140 lbs. per foot without any such pressure as often existed in a crowd.

There was also the question of roofs. Table 2 showed the loading of roofs of the various cities as extremely inconsistent. In London the snow rested heavily upon them; whilst he had seen ice a foot thick in Chicago. In Melbourne there was nothing of that kind, nor in San Francisco, and yet they supported their roofs twice as strongly as Chicago. If they reversed the figures it would be intelligible. The great majority of roofs were low, and were generally surrounded by parapets; and when tests were made on a model with a blowing machine to find what the wind pressure was it was found to be practically nil. In Melbourne they had no snow, so what the roofs had to carry he did not know. And yet he saw roofs in many places which were abnormally heavy. He had asked the question on one occasion as to whether they intended running a locomotive engine over the roof. He was once discussing the question of wind pressure with an architect, who laughed at it—and rightly so. He made the remark that he had never known a roof to be crushed by wind pressure, but had often known it to be lifted off.

With respect to such buildings as Gothic churches, which were placed in a different category to other buildings, they had steep roofs which did receive some wind pressure, but much less than most writers of books on the subject supposed. At the Stamford University it was noted that the buildings that suffered from the earthquake were those which had roofs which were not tied, whilst security lay in having a tie beam firmly attached to the walls.

He would congratulate Mr. Henderson on the valuable paper submitted. He had introduced a most consistent system of wall thickness, and certainly his industry had rendered a great public service.

Mr. A. Henderson said he would prefer to reply at a subsequent meeting. One reason for desiring this was the fact that the Melbourne new regulations would probably be published before next meeting, and it would be very useful to have the views of the Institute of Engineers upon some of the doubtful points. The main object of his paper was to arrive at a proper analysis in connection with building regulations, and he regarded the analysis on page 61 as one of the most important features of the paper; also the analysis of the risk of fire on page 63 was very important. He considered that any modern scientific act should
be passed upon some such analytical conditions. With regard to brick walls for new buildings, he was rather of Major Monash's opinion, that they would soon be a thing of the past, but there were hundreds of brick buildings in Melbourne waiting to be raised, and they could be raised without difficulty if a sensible schedule of thickness was adopted.

PAPER.

RECENT TUNNELLING OPERATIONS FOR THE SEWERING OF THE CITY OF MELBOURNE.

By Major H. V. Champion.

On deciding to extend the Melbourne sewerage system from Richmond to Hawthorn it became necessary to once more cross the river Yarra.

Several sections of sub-aqueous work had already been constructed, the first being the inverted siphon under Stony Creek, on North Yarra main section No. 1 (see Minutes of Proceedings The Institute of Civil Engineers, vol. cxxxiii., pages 351 to 362, inclusive), closely followed by the tunnel on the Hobson's Bay main under the Yarra at Spotswood, where the disastrous inburst occurred which caused the death of the engineer, Mr. Buchanan, and several men. This contract was then abandoned by the contractor, and the work was re-let to Mr. A. G. Shaw, C.E., who successfully completed it.

The Melbourne main sewer crossed the Yarra at Dudley street, and was constructed within a steel tube, which was floated out into position and sunk on a prepared bed. It again crossed the river at South Yarra near the Cremorne railway bridge, and was constructed in a similar manner, except that the tube was sunk in sections, which were joined together afterwards at the bottom of the river.

The North Yarra main sewer crossed the Saltwater river near Dynon-street, and was also constructed of a steel tube sunk in sections on a prepared bed.

All these works having been completed, considerable experience had been gained by designers and constructors in the method of overcoming the difficulties incidental to such operations, and the design adopted at Hawthorn was an inverted siphon to get cover enough to tunnel under the stream.

This, however, was merely one section of the contract let to Mr. A. G. Shaw, and known as section No. 1, Hawthorn Main Sewer. The contract extended from the corner of Burnley and Mur-
THE QUEBEC BRIDGE DISASTER.

Mr. JAS. ALEX. SMITH said that one point in the author's parenthetical remarks which appealed strongly to him was the reference to the necessity for completeness in physical testing as a complement to purely mathematical deduction. Upon the evidence before them, it would seem that had tests to destruction of large scale models of the chief typical components been made, the disaster might have been averted. The cost would have been fully justified.

The illustrations which had been exhibited showed the designs for the completed bridge, and the wreck. A copy of "Engineering" that had reached him that afternoon reproduced a photograph of the bridge as it was fifteen days prior to the failure. There had not been time to prepare a lantern slide, but he had, as would be seen, sketched the illustration on the blackboard. It would be noted that a traveller, weighing 1000 tons, near the end of the cantilever, had been partly removed, hence the dead load at the time of the wreck was somewhat less than it had been at a previous period.

BUILDING REGULATIONS.

The discussion on Mr. A. Henderson's paper was resumed. Major H. V. CHAMPION asked if the thickness of walls was affected by the materials of construction. He understood the scheme applied to any class of brick work. Was any difference made in the case of cement as against lime mortar work?

Mr. A. HENDERSON, in replying, said Major Champion's question could be speedily answered. The diagram showed a standard wall which he had designed for the suburban conference, and consisted of three stories of brick work of each thickness, the bottom story of each thickness strengthened by piers. If built in cement it would be allowed two more stories. Where a wall was built in cement, or had acquired elastic resistance through being old, it should be allowed to have a thinner top story. His suggestion was to have two grades lower, but the conference adopted one.

He thoroughly agreed with Mr. Little that it was useless to attempt to reform the building regulations, and in his scheme he had adopted what his judgment accepted after fair and if anything conservative treatment. Mr. J. A. Smith had referred to the question of frosts in Toronto.
If they looked at the diagram they would see that Toronto had the lightest walls in the world for domestic structure, except Liverpool. Evidently they did not build in frosty weather. But there was a peculiar and unscientific thickness of the wall at the base. He was under the impression that the thickening of some of those walls at the base was to obtain a better stability; but he found that that did not hold.

Another remark of Mr. Smith's, he thought, must be a misprint—"But there might be eight or ten or eleven stories alternatively, to a given height. With the greater number of stories there might be greater loading; certainly there would be more transverse tieing of the structure." The fact was this:—In the scheme he proposed there was a thickness for every story. If they had eight stories they had thicker walls as they went down. It was the grade of the wall only that was affected by the height.

Mr. Smith had raised a very good point as to unsymmetrical foundations, and he (the speaker) had made a calculation as to some foundations and a diagram also to show the effect of the loading on the walls. It was very often supposed, and naturally too, that with the thicker wall a better distribution of weight on the foundations was obtained. The diagram represented two walls, the new suburban wall, and the present Melbourne wall. The portion hatched represented the equivalent in brickwork of the floor load at 1 1/2 cwt. per foot as it affected the wall. Calculating the different centres of pressure he got some rather remarkable results. Taking the new suburban wall and assuming the 1/2 brick at 4 inches they got a wall 24 inches in thickness at the bottom, and the centre of pressure of that wall without loading was 9 3/8 inches from the outside and 14 1/8 inches from the inside, consequently that wall would have a tendency to fall outwards. The Melbourne wall was 32 inches thick, having a centre of pressure 12 3/4 inches from the outside and 19 3/4 inches from the inside, and would have a similar tendency. Assuming 3 cwt. per foot loading the old Melbourne wall gave 16 1/4 and 15 1/4 inches for the centre of pressure and the suburban wall gave 12 3/4 and 11 1/4 inches. These were the dimensions without any projecting footings and the corresponding foundation pressure was 4 tons per square foot for the walls alone and about 7 tons for the loaded wall. Four tons was a very common Melbourne pressure, but 5 tons was often permissible. In order to bring the larger pressure for the loaded wall down let the thickness of the bottom be increased 50 per cent. by footings. Then the position of the centre of pressure became 12 3/4 and 23 1/4 for the suburban and 16 3/4 and 31 3/4 for the Melbourne, being almost the same proportional difference of pressure in each case and showing a very considerable increase of pressure on the heel of the wall compared with what there was on the toe. This probably accounted for the rule in England that if they possibly could builders must project their footings on their neighbour's land, and if not the neighbour probably bore some of the lateral pressure. It showed how very
He had to thank Professor Kernot for the very kind way in which he had spoken of his wall. It had not been arrived at by accident. It had been worked out very carefully and after spending a long time on the analysis of its various departments. Here he might note that in Minneapolis the walls which were not strengthened by piers, and which had not to support any heavy weight, had to be thicker if they exceeded a certain length. Professor Kernot seemed to think he should have said something more about factors of safety. He had known buildings which had been standing as warehouses for twenty-five years, and portions of these buildings had a factor of safety of not more than three. He was on an inquest at one time when an expert witness gave evidence that a factor of less than 10 was unsafe every time. That was an old-fashioned factor of safety, and might be right in the case of timber exposed to weather, but he thought it would be a good thing if the Institute appointed a sub-committee to consider the question generally. The whole subject should be thoroughly thrashed out.

The President said this finished the formal discussion, although it did not exhaust the subject by any means. The question of the factor of safety was one upon which an immense deal could be said.
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