Explanations and Calculations
accompanying a
Thesis "Design" for a Town "Hall."

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Among the various subjects from which we were allowed a choice ~~for~~ our thesis, that of a Town Hall for many reasons is the one most interesting to me.

Architecture in our country towns is comparatively a new thing.

For generations we have been contented to build after the same old model, and the result is, that riding through one of our ordinary country towns, one who has cultivated any taste for the art, is painfully struck by the monotony and total lack of Architectural spirit displayed by the various buildings which he passes.

Within a few years the subject of Architecture has come to play a more important part in the interests of our New England people.

This is due in a great measure, I think, to the copious draughts of education which have been so generously spread

broadcast over our whole country.
Just in proportion as a people grow richer and more cultivated, so do the Fine Arts, of which architecture is no second rate element, become more and more an object of their attention.
To the ignorant and vulgar taste, shelter, warmth and convenience are the only requisites which make the sum total of any building. In saying this I do not mean to say that these qualities should be neglected or despised, on the contrary they should be made the most of, and it is just the architect's business to combine these necessary and useful qualities, with such forms as will give pleasure to the eye.
There are ever two sides to human nature the "matter of fact" or commonplace, that which causes a man to look sharp after the necessities and ordinary comforts of life, and the aesthetic, that higher sphere of man's, where its in the intellect which seeks satisfaction

and this is the part of man which grows most under educational training.
Granted then that our American people are fast attaining a love for the artistic it is our business to design a public building, a "Town Hall", something in which every member of the town is interested, for one of these towns whose people have felt for some time this aesthetic influence.
The town contains some four or five thousand inhabitants, quite a number of whome are wealthy and take considerable interest in town affairs.
It is desired that the building be constructed in stone, and as the spirit of Gothic architecture prevails with the majority of the citizens, it is to be built in the Gothic style after the most approved design.
The building is to set north and south and to face toward the south. It is to be

built two stories in height and to be of sufficient size to contain all the necessary town officers' rooms, besides a library room and a large hall for public purposes.
As a principal outside feature it is to have a clock tower with a dial on each side, so that the time may be seen from the four points of the compass.
Various rooms required. as follows:,
Vestibule and main hall; separate rooms for town clerk, selectmen, tax collectors, school committee; a small hall for incidental purposes, such as caucuses and small public gatherings, a large and well-lighted room for a town library and reading room, a large and convenient staircase leading to ~~th~~ large hall, ~~about~~ its stage, dressing rooms and ante-rooms occupying the whole of the second floor, and a small staircase leading to the stage, besides numerous closets &c.
Taking then these requirements we have endeavored to fulfil them, making such alterations and additions as seemed most wise in the progress of the study of the design.

The Design.

After careful study a plan resembling the letter T was decided upon as the best and most artistic solution of the problem, the head of the T emphasizing the front of the building by giving it greater width. In any building it adds a great deal to the design, if the exterior is made so as to show the interior arrangement, so that from an exterior view some fair idea can be had of the general disposition inside.

Holding this principle in view the design has been studied as follows;

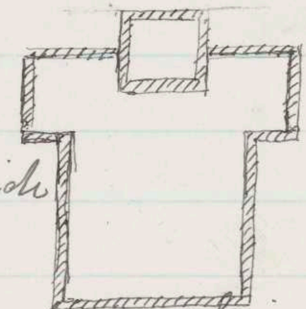
The front projection, that part of the building supporting and immediately adjoining the tower, has been carried up some four or five feet higher than the main building so that the cornice is so much higher than the cornice on the main building. The roof being very much narrower is of course lower than the main roof. In this way we mark the front of the building showing that it has a purpose different from any other part, that of holding up the tower. Also at every landing of the front staircase a line of mouldings has been carried across on the outside showing distinctly the height of each landing from the outside.

The main hall being the principal room in the building is plainly marked in in several ways. 1st The roof covering it is treated as the main roof being several feet higher than the others. 2nd The side walls although being in the same vertical plane on the inside, at that point where the hall ends, is on the outside, set back six inches, making a thinner wall for the rear of the building, and giving a sharp and decided line marking the end of the hall. Also the balcony running along the side is shown by a line of mouldings and a blank space the height of the balcony, breaking up the side windows into two parts.

The rooms in rear of the large hall are dressing rooms, and are much lower than the ~~maige~~ hall. accordingly the cornice is dropped 10 feet and those rooms covered by a lower and flatter roof in one pitch making a symmetrical half gable at the back.
The opening for the stage needs to be as high as possible; to do this, the cornice to the roof covering the stage is carried back again to the height of that of the main roof, making a continuous cornice around ~~both~~ parts, the walls being supported, one by a thick partition wall and the other by iron columns in the small hall below. This gives a rear elevation (not shown in the drawings) of this form.

Sketch of the rear elevation above the second floor. Here again the outside wall directly in rear of the stage is made six inches thicker (equal to the thickness of the wall to the main building), distinctly mark-

ing the stage from the dressing rooms.
The stairway leading to the stage is shown on the outside by two small windows at different heights one at each landing. All of these points may be seen plainly from the drawings, but they are mentioned here in order to set forth the principal points of interest and study in the design. The first plan that was seriously considered was of a form thus, it being the idea to make the tower the whole width of the front projection, which was twenty feet. After a good deal of careful study this idea was abandoned, the tower being much too heavy and clumsy for the size of the building.



It was accordingly thought better to widen the front projection four feet and then to cut the tower down to twelve feet, supported in front by the front wall of

the building and at the back by two thick granite piers as may be seen from the drawings.
In this way the piers serve as supports for the tower and also for the staircases.
With the exception of this change, the plan was carried out as originally intended, considerable difficulty being experienced in making the side windows and door come symmetrical both inside and out.

General disposition of the interior.
The first floor is five feet above the level of the side-walk.
The front entrance and vestibule are on a level with the ground, and an easy run of steps inside reaches the front hall, which is large and spacious (32' x 10').
Opening from this hall with its corridor are all the rooms on the lower story.
On the right directly as you enter is the tax-collector's and assessor's room 10' x 14'.

fitted with a permanent counter and wicket.
On the left, and corresponding exactly in size and situation is the town clerk's office, fitted up in the same manner, with a fire-proof vault for town records, leading directly out of it.
Next to the tax collector's office is the janitor's room occupying the end of the hall; the end opposite is filled by a closet and the fire-proof vault.
Opposite to the front entrance is a corridor running back to a rear hall.
On the left side of this corridor is the town library, a large and convenient room 16'x28 which is fitted with book cases, a counter and stile for the librarian and a large reading table for the public.
On the right of the corridor are the selectmen and school-committee rooms, respectively 16'x15' and 11'x15'.
At the rear, and occupying the whole of the back of the building, with the exception of a small

staircase, is a small hall 20' x 30': for caucuses, small public gatherings &c.; furnished with a small permanent stage 8' x 11' and 2' 6" high.

The staircase to the stage above, runs directly back of the stage in the small hall, and is so managed as to have a landing, at the same height of that stage, directly in the center of the back, so as to give an entrance at the back of the stage.

Beneath the stairs is a small closet opening from the stage.

The front staircase starts from the front hall in two parts, each six feet wide; goes half the height of the story to a broad landing 8' x 20'; and thence, in one part, 8' wide, to the vestibule (the same size as the front hall), of the large hall.

Leading off from this vestibule are two suites of dressing-rooms; one for ladies, and one for gentlemen; each suite comprising, a cloak-room, a toilet-room and

water closet. The rest of the second floor is taken up with a large hall 40'X40' with its stage and dressing rooms. The large hall is designed for public use, such as town meetings, lectures, balls and theatricals.
For this purpose, it is fitted with a large stage 15'x20', and a ladies' and gents' dressing room.
For convenience in getting upon the stage, there is a passage, three feet wide, behind, with steps leading up at each side.
The large hall has three galleries, or balconies, one at the front, and one on each side. The front gallery is supported by partition walls, while those at the sides are supported by heavy wooden brackets.
These galleries are reached by a staircase, of exactly the same plan as the lower flight. All of the staircases are ranged to come, one over another, by which means all the room is economized.

From the landing at the height of the gallery, there is a circular staircase running up to the clock tower above.
The large hall is covered by an open timber wooden roof, the trusses coming down and making a composition with the brackets supporting the side galleries.
The gallery at the front is recessed back from the hall, the face of the recess being a big arch of the same shape as the roof truss.
The side galleries are entirely separated from the front, and are reached by a door opening through the haunch of the big arch.
For convenience in getting to the seats in the side gallery, the platform for each row of seats, is made wide enough for a person to pass in front of one seated

On the gallery floor there are two dressing-rooms for the persons occupying those seats.

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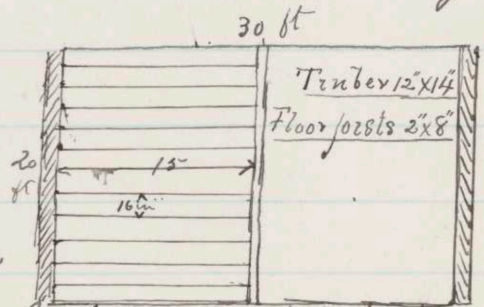
Calculation of the floor over the small hall.
This is the only floor in the building which requires a beam to support the flooring joists.
The room is 20' X 30' and it is thought best to put a beam in the middle of the space, dividing it into two bays 20'X15' each. making the flooring joists 15" long.



Allowing an average weight of 40 lbs to the square foot; as large a load as is ever liable to be put upon it

Total weight allowed for live load = 24000 lbs
Weight of floor and timber 2500 "
" of stage 1920 "
Total weight on floor = 28420

$\frac{1}{2}$ of this load is supported by the two walls, and one half by the beam.
The formula for the size of a beam under a given load, allowing the beam to deflect only such a part of its length ($\frac{1}{480}$) for safety is

$\frac{l^3 \times W}{d \times c} = b h^3$ where l = length, b = breadth
W = load at middle, h = height
d = deflection
c = constant

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applying this formula, and using as a constant for deflection for spruce 5072 (Andersen) and taking half of the uniformly distributed load as the load at the middle,

$\frac{20^3 \times 7100}{.5 \times 5072} = bh^3$. and taking 12" as a desired depth, $b = 12"+$

Therefore taking a 12" × 14" stick, and allowing 2" for gains, we have left an effective section of 12"×12", the section desired.

For flooring joists, it is desired to set them 16" apart on centers. The space of one bay is 20 ft, therefore there will be 15 joists.
The floor is to stand a load of 45 lbs per sq. ft., therefore the joists being spaced 16" apart will each have to bear a load of $1\frac{1}{3} \times 45$ or 60 lbs per running foot. Load on a joist = 15 × 60 = 900 lbs uniformly loaded, taking ½ this load as the load applied at the middle we have W = 450

$\frac{15^3 \times 450}{.375 \times 5072} = bh^3 \therefore bh^3 = 785.$ and taking

2" for b h = 7.5+ 2"×8" would be the size of joist used.

Calculation of Roof Truss.

In calculating the strength of roof timbers, there are always two kinds of forces which must be taken into consideration:

1° The dead load of the roof, which takes also the weight of snow.

This force always acts vertically downwards, which causes compression, and also a bending moment, in the rafter

These forces can be found by taking the total load, and resolving it into normal and tangential components, that is, normal and tangential to the roof.

2° The second force is that of wind pressure, which may be taken without error as acting normal to the roof.

This pressure varies for different slopes, and is determined by a formula based on experiment.

In the case of the truss which we are considering, the angle of the roof is 45°

Roof Truss

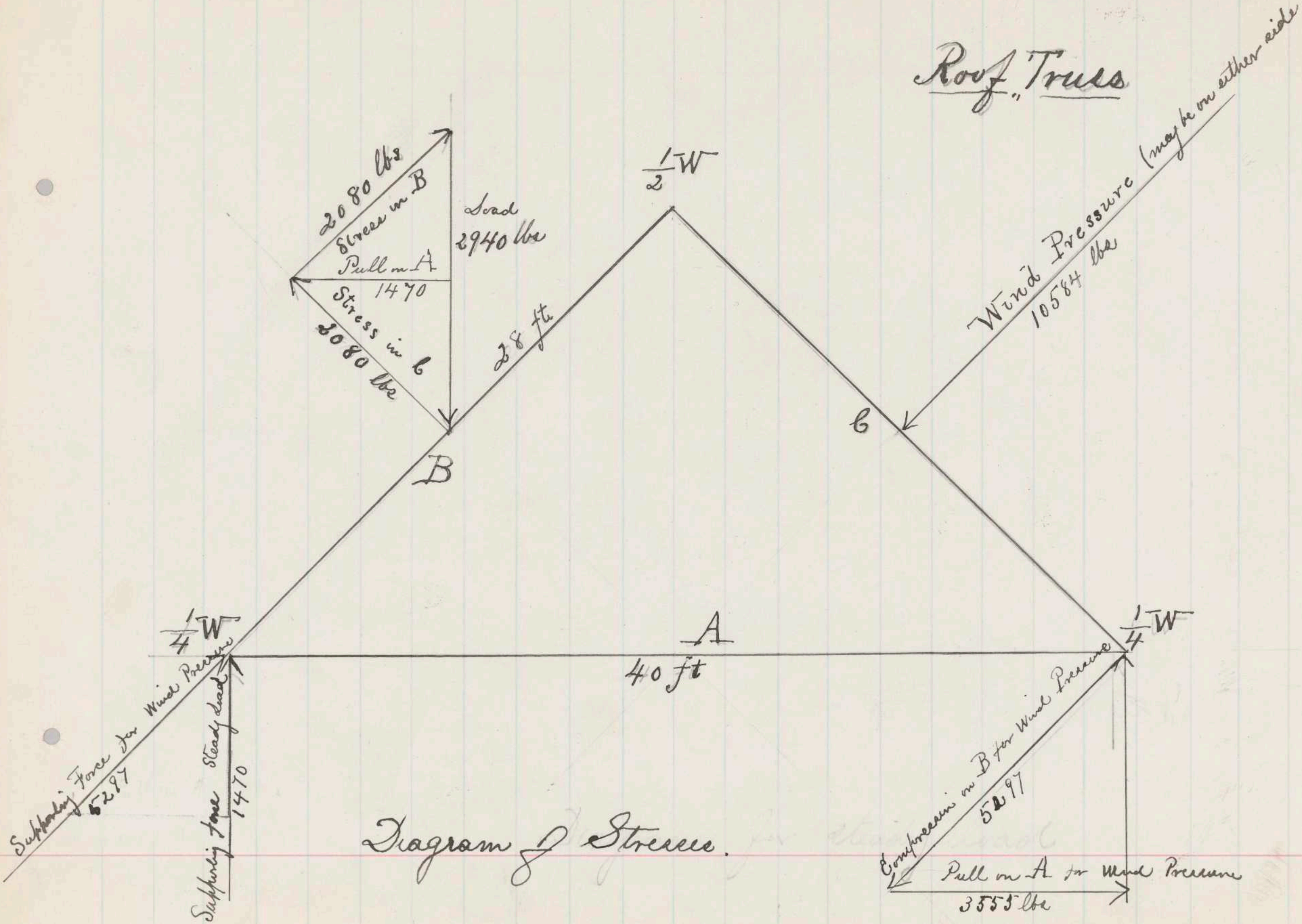

Diagram of Stresses.

the shape is as given in the diagram.
In the design there is an arched rib of woodwork but it is for an ornamental purpose only, and will not be taken into consideration in the calculation, as it is desirous to have the truss strong enough to supports the weight independantly
In this case the load will be taken as uniformly distributed, the purlins being placed near enough to allow this to be done without error.
The trusses are 10 ft 6 in apart on centers and are 28 ft in slant height
Total area of surface to be supported = 10.5 × 28 × 2 = 588 in
Taking 10 lbs as the weight per sq. ft. for dead load, including wt. of snow, which will be small, as the angle is greater than the angle of repose; we have
Total load on truss = 588 × 10 = 5880 lbs. $\frac{1}{2}$ of is supported on each wall.
Of the load on each rafter, $\frac{1}{2}$ is at the top and $\frac{1}{2}$ on the wall plate, which gives $\frac{1}{2}W$ at the top joint and $\frac{1}{4}W$ at the wall joint.
Drawing our diagram of forces (we here make use of the principle of the "triangle of forces"),

We find the several stresses in each bar.
1° A pull on the bar A of 1470 lbs
2 A thrust on the bar B (C same) of 2080 lbs
As the angle of the roof is 45°, the tangential and normal components of the load will be equal, and we shall have a weight of 2080 lbs which produces a bending moment in the beam. To find the size of B required to support this load

1° To resist bending moment

$$M_0 = \frac{Wl}{8} = \frac{1}{6} f b h^2$$

W = total wt.
l = length of rafter in inches
f = a constant
b = breadth of rafter
h = depth " "

$$\frac{2080 \times 336}{8} = \frac{7200\, bh^2}{6}$$

$bh^2 = 75$ and taking a factor of safety 4 $bh^2 = 300$ assume $h = 12$ $b = 2$

2° To resist compression

$$Ps = \frac{fA}{1 + a\frac{l^2}{h^2}}$$

P = compression in rafter
S = factor of safety
f = constant
A = area of cross section
a = constant
h = least dimension
l = length of strut in inches

$P = 2080$
$S = 4$
$f = 7200$
$A = x$
$a = \frac{1}{250}$
$h = 2$
$l = 84$

$$2080 \times 4 = \frac{7200 \times A}{1 + \frac{1}{250} \cdot \frac{7056}{4}} \qquad A = 9 \text{ sq in}$$

The length of unsupported strut = 7 ft.; as there are four purlins which clamp the rafter and prevent it from buckling sidewise
For the pull in A it will be most convenient to wait until we get the pull caused by the wind pressure and add them together.

Wind Pressure This force can come upon but one side of the roof at once, therefore that is all that need be taken into consideration. This force can be taken without error as acting normal to the roof

Total pressure = $28 \times 10.5 \times 36 = 10584$ lbs

36 lbs being taken as the maximum pressure which is liable to come upon a sq. ft.

To find size of beam required to support this wt.

$$M_0 = \frac{Wl}{8} = \frac{1}{6} f b h^2$$

$$\frac{10584 \times 336}{8} = \frac{1200\ bh^2}{6}$$ $bh^2 = 366$ and using a factor of safety 4. $bh^2 = 1464 = 10 \times 12$

Adding to this, the section necessary to withstand the first bending moment, and the compression in the rafter, we get a necessary section of 12" × 12" or a rafter which would be better and stronger 10 × 14"

We have yet to take into consideration the compression caused by the wind pressure, in the opposite rafter. The roof being 45° the thrust is direct and equal in amount to $\frac{1}{2}$ the wt. tending to bend the rafter. Taking the formula for struts already mentioned, and substituting the values which we have already found for the rafter; we find that the cross section necessary to resist bending is greater than necessary to resist compression, so that we need not take into account this compressive force.

It will be noticed that in this truss the supporting forces for wind pressure, are equal.

Pull in A Adding together the pull due to the dead load and that due to wind pressure we have 1470 lbs + 3555 lbs = 5025 lbs

$$A = \frac{Ps}{f} = \frac{5025 \times 4}{7200} = 3^{\square''}$$

This would be sufficient if there was no weight on A, but the ornamental rib has a straight piece coming down in the middle of A, which will produce a slight bending moment, besides the shearing force of the tie. It will be an ornamental piece, and in order to be of sufficient size to look well, will have a cross-section much larger than is necessary to withstand the forces acting upon it.

Calculation of beams and columns supporting the wall, before mentioned, between the dressing room and stage.

The wall is 18" thick 20' long and and 24' high, 16' of which is brick-work, and 8' stone-work as it shows from the outside.

Weight of brickwork = 150 × 480 = 72000 lbs

" " stonework = 175 × 240 = 42000

Total weight of wall = 114000. lbs.

Weight of roof supported on the wall

Rafters 513 lbs

Slating & boarding 1570 lbs

Supporting force necessary for wind pressure 5652 lbs.

Total weight of roof = 7735 lbs.

Total weight on beams 121735 lbs.

The best way of supporting this weight, is by two iron columns. This will give a span of 7 feet unsupported beam.

Of course the beam could be calculated by Rankine's method of equating the greatest bending moment of the beam, to its moment of inertia, but the Phoenix, Cooper & Hewitt and in fact almost all of our large iron manufacturers, have furnished to the public, a complete set of tables, giving the strength for different sizes and shapes of the different forms of beams used in building, and as we have been taught to use them, and to place reliance upon them, it saves much time and labor. and we may employ these tables in any calculation of iron beams and columns.

Total load on one span $= \frac{121735}{3} = 40578$ lbs

The 9in heavy beam (Cooper, Hewitt & Co) 8.32 sq in cross section will bear safely a uniformly distributed load of 22000 lbs, with a span of seven feet. Taking two of these beams we have the necessary strength to support the wall and roof.

The columns supporting this load can also be calculated from tables given by the Cooper, Hewitt. The 5in outside diameter, thickness 1¼" length 14 ft will bear safely a load of 31 tons. It will bear this load in case the caps and bases have a perfect bearing, but in the process of ordinary building 1/2 of this load is usually taken as the safe load.

Total weight on beam = 121735 lbs

1/2 of which is supported on the wall

Weight on both columns = 60867 lbs

" " one column = 30434 " = 15 tons

Taking 1/2 the safe load of the 5 in column, we have 15.5 tons, therefore this will be the desired size of column.

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The floor in the large hall would be calculated the same as the previous calculation for floors, with the exception that the live load would be taken at 80 lbs per sq. ft.

In conclusion, we would merely add, that as we are not architects, there are, of course, many practical difficulties yet to be solved; but in point of design and convenience, the building has been very thoroughly studied, both by brown paper sketches and on tracing paper, so that, were they in condition, it would be quite an interesting addition to include them with the other drawings.