DESIGN STATEMENT

PROJECT TITLE: Hull city artwork
PROJECT NO. 4167
DATE: 01/06/2017

report ver: 03
Prepared by: AL
Checked by: ET

Hull city artwork
Preliminary structural report

Contents

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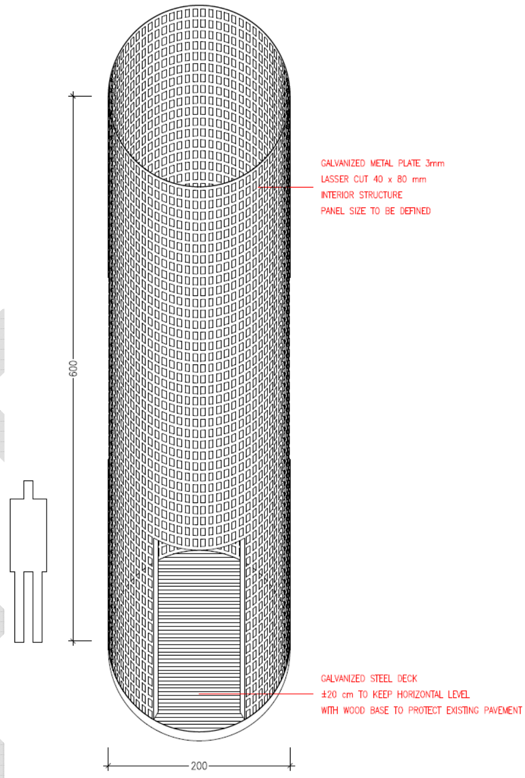
1.0 INTRODUCTION

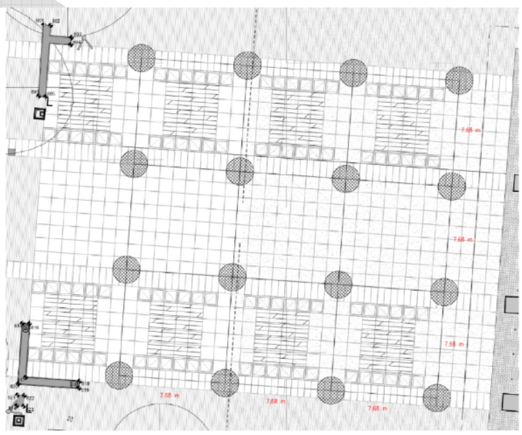
This report concerns a feasibility study for a proposed art installation in a square outside the Holy Trinity Church in the city of Hull.

The project is located in Hull, Yorkshire. The proposed installation is an 8m x 8m grid of 16 steel hollow columns.

The steel columns are designed with the following properties:

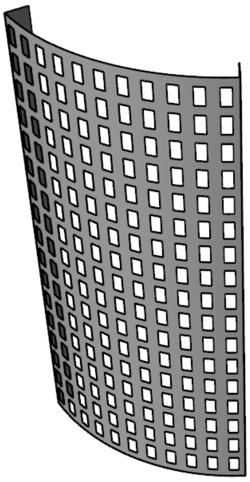
- Material: steel
- Shell thickness: 3mm
- Diameter: 2 metres
- Height: 6 metres

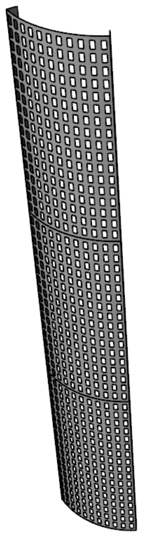


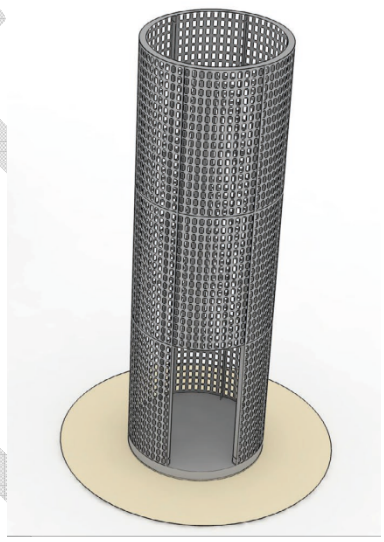


2.0 STRUCTURE

The structure is designed as a series of curved, perforated steel cassettes, which end with folded fins to allow bolting. Each steel cassette is 2m tall and is an arc 1/6th of the circular base.







Three steel cassettes, put on top of each other and connected with flat plates, form a full height element.

Six full height elements form the total cylinder. Those are further connected together with a top ring.

Over the entrance, only two steel cassettes are put together.

2.1.1 STRUCTURE VOLUME

The volume of one perforated steel cassette, not comprising the fins, is:

$$V_{SC} = 0.0045\ m^3$$

The volume of one full height steel cassette is:

$$V_{SC,FH} = V_{SC} * \ 3 = 0.0045 * 3 = 0.0135\ m^3$$

The volume of the entrance steel cassette is:

$$V_{SC,ENTR} = V_{sc} * 2 = 0.0045 * 2 = 0.009\ m^3$$

The volume of a single fin element, full height is:

$$V_{FIN,FH} = t * L * H = 0.003 * 0.1 * 6 = 0.0018 m^3$$

The volume of the top ring is:

$$V_{TR} = 0.002 m^3$$

Total volume of all steel cassettes:

$$V_{SC,TOT} = V_{SC,FH} * 5 + V_{SC,ENTR} = 0.0675 + 0.009 = 0.0765 m^3$$

Total volume of all fins:

$$V_{FINS,TOT} = 0.0018 * 2 * 8 = 0.0304 m^3$$

Total volume:

$$V_{TOT} = V_{SC,TOT} + V_{FINS,TOT} + V_{TR} = 0.0765 + 0.0304 + 0.002 = 0.109 m^3$$

3.0 LOADS

The wind pressure has been conservatively assumed as:

$$W_{pressure} = 1{,}5 \frac{kN}{m^2}$$

The area exposed to the wind pressure has been conservatively considered as:

$$A_{exposed} = D * H = 2 * 6 = 12 m^2$$

The total wind load has been calculated considering a triangular distribution of the pressure from bottom to top. The total wind load is therefore:

$$W_{TOT} = W_{pressure} * A_{exposed} = 1.5/2 * 12 = 9 kN$$

The structure weight as been calculated assuming a steel density of:

$$\gamma = 76.98 \frac{kN}{m^3}$$

Structure total weight:

$$P_{TOT} = V_{TOT} * \gamma = 0.109 * 76.98 = 8.4 kN$$

4.0 DESIGN

To have a stable system, the stabilizing moment has to be more than the overturning moment. In addition, a safety factor of 1.2 has been considered:

$$M_S \geq 1.2 * M_O$$

The overturning moment is calculated considering the wind resultant force applied at 2/3rd of the total height, as a triangular distribution of the pressure was assumed.

$$M_O = W_{TOT} * \frac{2}{3} * 6 = W_{TOT} * 4 = 9 * 4 = 36 kNm$$

The stabilizing moment is calculated as the weight force, applied in the barycentre of the cylinder, multiplied for a lever arm from the cylinder edge:

$$L_{lever} = \frac{D}{2} = 1m$$

The stabilizing moment will include an additional stabilizing weight P_{ADD}, which will be given by an additional steel disc. This disc will be the base of the structure, and the cylinder will be built attached to it.

$$M_S = (P_{TOT} + P_{ADD}) * L_{lever} = 8.4 * L_{lever} + P_{ADD} * L_{lever}$$

Hence, the additional weight P_{ADD} must be at least:

$$1.2 * M_O = (P_{TOT} + P_{ADD}) * L_{lever}$$

$$1.2 * 36 = 8.4 * L_{lever} + P_{ADD} * L_{lever}$$

$$P_{ADD} = \frac{1.2 * 36 - 8.4 * L_{lever}}{L_{lever}} = \frac{1.2 * 36 - 8.4 * 1}{1} = 34.8kN$$

4.1.1 BASE DISC DESIGN

The base disc is designed as a full steel plate connected to the superstructure. Its thickness t needs to be designed to give at least the required additional weight P_{ADD}.

$$A * t * \gamma \geq P_{ADD}$$

$$(3.14 * 1^2) * t * 76.98 \geq 34.8$$

$$t = \frac{34.8}{3.14 * 76.98} = 0.144m = 144mm$$

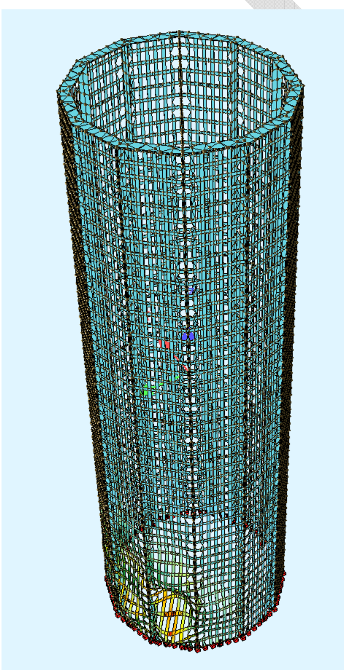
5.0 ANALYSIS

A meshed model of a single cylinder has been analyzed in SOFISTIK.

The loads and loads combination considered are:

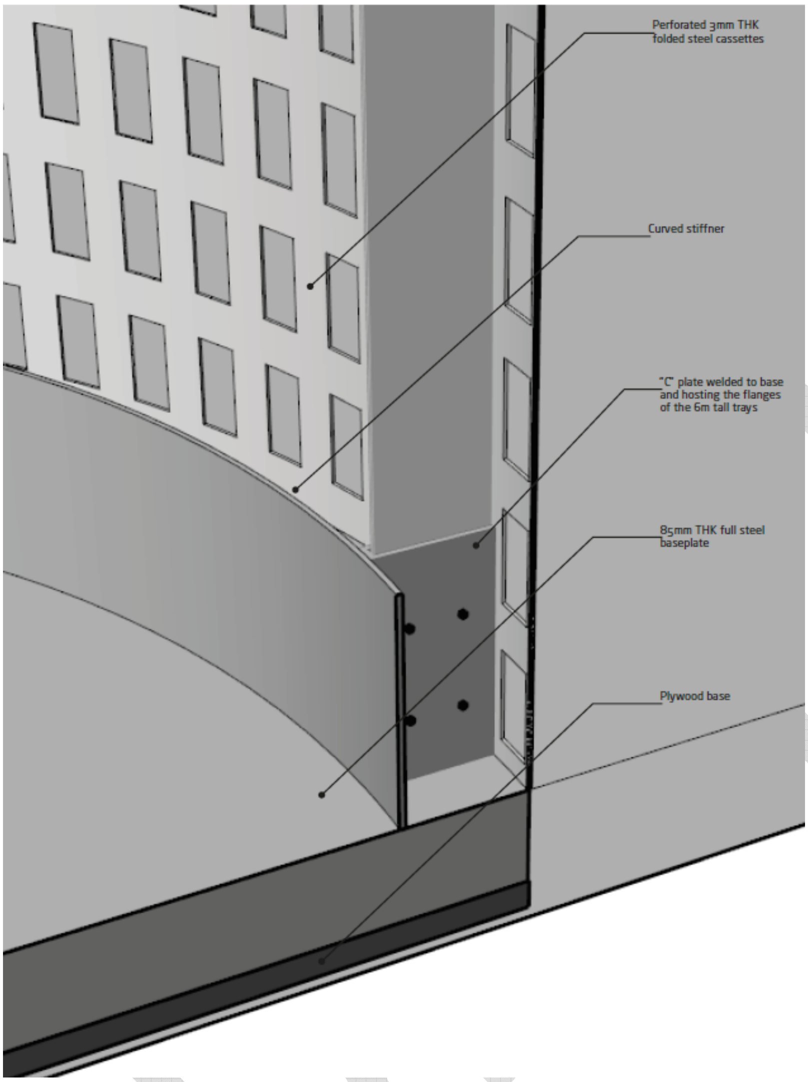
Loads: DL Wind – 1 direction only

Load combinations: DL+Wind Buckling



The fist buckling factor is 4.28, corresponding to an instabilization of a bottom perforated steel cassette in correspondence of the leeward side, where the largest compression stresses are located.

6.0 DETAILS



Perforated 3mm THK folded steel cassettes
Curved stiffner
"C" plate welded to base and hosting the flanges of the 6m tall trays
85mm THK full steel baseplate
Plywood base

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