

Redevelopment Grote Marktstraat
Multidisciplinary lighting design

The Grote Marktstraat in The Hague is undergoing complete refurbishment using a design made by ELV Architects. This assignment is commissioned by the Municipality of The Hague. Arup is involved as the designer of the lighting and the tensegrity structure of the street lighting system. The plan consists of so-called chandeliers and vertical elements.

The functional lighting is provided by lighting fixtures that are integrated in the structure. Another group of fixtures is incorporated into the chandeliers; this group provides the dynamic and colored lighting. The intensity and color of the light depends on the amount of people that are in the chandelier's proximity.

The chandeliers and the vertical elements are constructed as a 'tensegrity', a structural system comprised of compressed struts in a net of continuous tension. The struts do not touch each other and are fixed in position by the pretensioned cables. Lighting fixtures are integrated at the ends of the "floating" struts.



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Overview street

Grote Markt/Spui

Connections

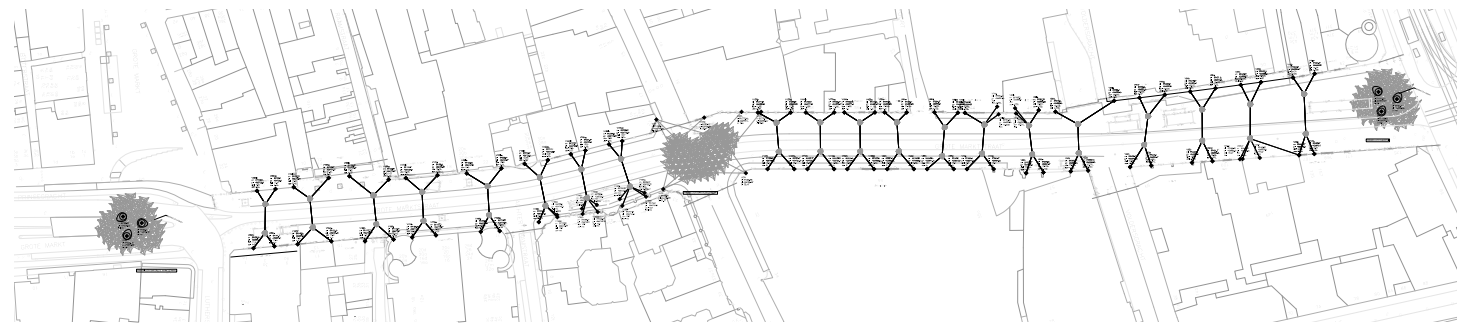
Wagenstraat

Connections

Lighting design

Vertical Elements

Connections



Overview street

Grote Marktstraat, The Hague

The redevelopment plan of the Grote Marktstraat consists of three chandeliers which are positioned at the street's three main junctions, and 20 sets of vertical elements which are hung in the street.

The chandeliers on the Grote Markt and the Spui are identical. These tensegrities are hung from three columns, named the "tripod column", whereas the chandelier on the Wagenstraat hangs from the surrounding buildings.

The chandeliers and the vertical elements use the structural principle of tensegrity. Tensegrity literally means the combination of tension and integrity. Tensegrities describe a structural system comprised compressed struts in a net of continuous tension. The struts do not touch each other and are fixed in position by the pretensioned cables. This clear distinction between compression and tension creates structural integrity.

Overview street

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Chandelier Grote Markt/Spui

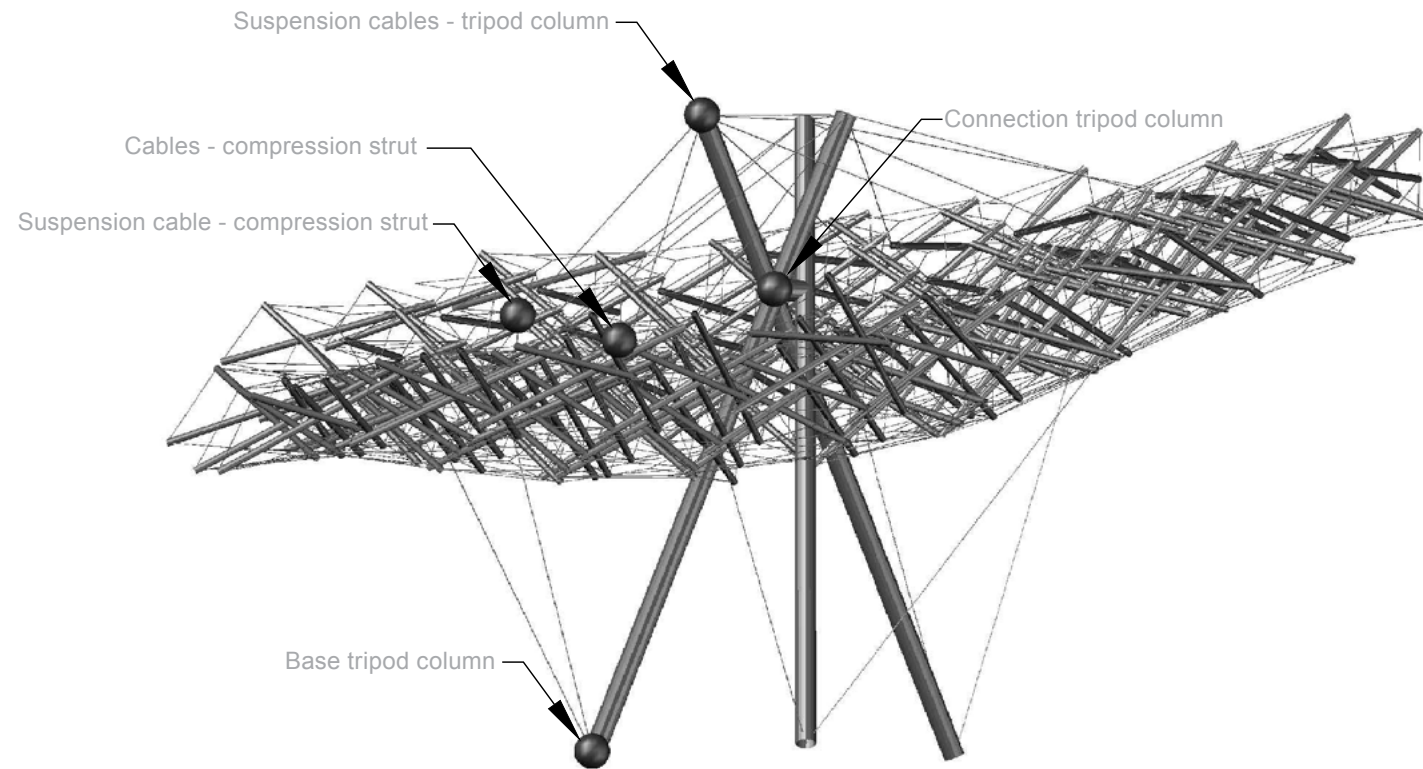
General information

The chandeliers on the Grote Marktstraat are structural systems of linked tripod modules: a tensegrity element built up from three struts of which the ends are connected to three cables.

The tripod modules are connected in a way that the tensegrity expands in two dimensions. The modules are linked in a horizontal plane, keeping the tripod as a whole intact; extra cables at the top and bottom of the modules are added for more stiffness. Two types of chandeliers are created for the Grote Marktstraat: one in a concave shape (Grote Markt/Spui) and one in a convex shape (Wagenstraat).

Lighting fixtures are incorporated in the struts of the structures to provide the street lighting. Another group of fixtures is integrated to provide dynamic colored lighting. The intensity and color of the light varies according to the amount of people in the chandelier's proximity, as detected by sensors. On festive days the lighting scenarios can be adapted to different themes.

3D model chandelier Grote Markt/Spui



Overview connections chandelier Grote Markt/Spui

Chandelier Grote Markt/Spui

Connections

Key feature in the design of the tensegrity is the connections. Each end of each strut is connected to six cables. Each cable is connected to a fin plate by a pin connector. These fin plates are connected to a central tube that transfers the load to the struts via an end plate. At the other ends of the connections, the lighting fixtures are placed.

The chandelier Grote Markt/Spui is hung from a tripod column with suspension cables. These are connected to the standard end connection of the struts. At the connection points of the supporting structure and the suspension cables, the cables are attached to the tripod column with pin connectors. Just above the tensegrity net the three columns of the tripod column are connected. Under this link data- and electricity wires are lead from the column to the tensegrity. On ground level the column is attached to the foundation, and the data and electricity wires are connected to the hardware operating system.

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Cables - compression strut

Chandelier Grote Markt/Spui

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Overview connections

Structure

Light

3D Impression

Section A-A

Section B-B

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Cables - compression strut

Chandelier Grote Markt/Spui

Connections

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Overview connections

Structure

Light

3D Impression

Section L-L

Section M-M

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Suspension cable - compression strut

Chandelier Grote Markt/Spui

Connections

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Overview connections

3D Impression

Section C-C

Section D-D

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Suspension cables - tripod column

Chandelier Grote Markt/Spui

Connections

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Overview connections

3D Impression

Section E-E

Section F-F

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Connection tripod column

Chandelier Grote Markt/Spui

Connections

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Overview connections

Structure

Light

3D Impression

Section G-G

Section H-H

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Connection tripod column

Chandelier Grote Markt/Spui

Connections

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Overview connections

Structure

Light

3D Impression

Section G-G

Section H-H

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Base tripod column

Chandelier Grote Markt/Spui

Connections

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Overview connections

Structure

Light

3D Impression

Section J-J

Section K-K

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Base tripod column

Chandelier Grote Markt/Spui

Connections

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Overview connections

Structure

Light

3D Impression

Section J-J

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Chandelier Wagenstraat

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3D model chandelier Wagenstraat

Overview street

Grote Markt/Spui

Connections

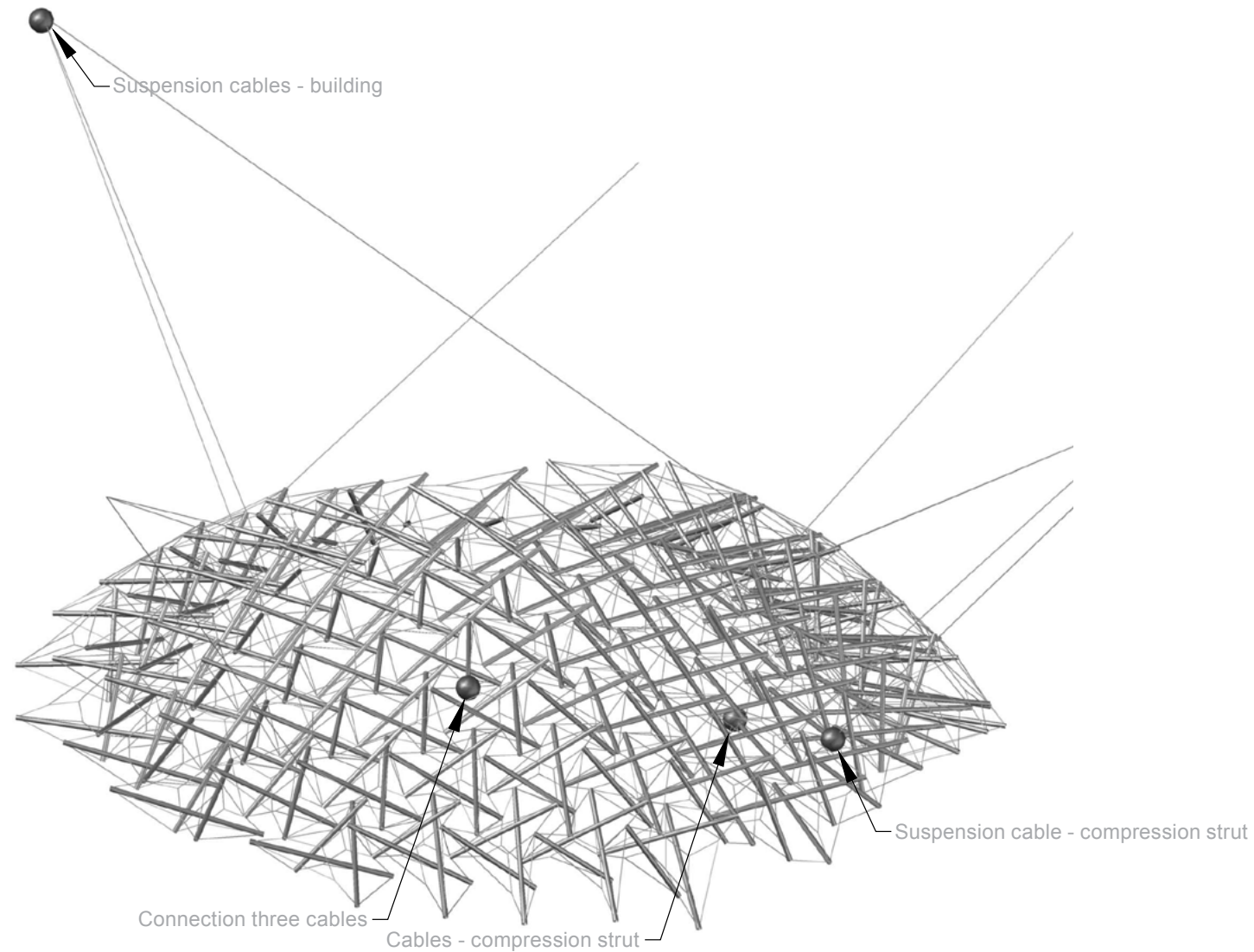
Wagenstraat

Connections

Lighting design

Vertical Elements

Connections



Overview connections chandelier Wagenstraat

Chandelier Wagenstraat

Connections

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The chandelier 'Wagenstraat' is placed above the Grote Marktstraat-Wagenstraat crossing, hanging from cables attached to the surrounding buildings. These cables are connected to the standard end connections.

Data and electricity cables are carried by the suspension cables to the tensegrity. The maximum length of the data and electricity cables is optimised. Besides the lighting on the ends of the struts, additional lighting fixtures are integrated in the nodes of the three cables, which are typical connections in the chandeliers.

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Cables - compression strut

Chandelier Wagenstraat

Connections

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Overview connections

Structure

Light

3D Impression

Section A-A

Section B-B

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Cables - compression strut

Chandelier Wagenstraat

Connections

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Overview connections

Structure

Light

3D Impression

Section L-L

Section M-M

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Suspension cable - compression strut

Overview connections

3D Impression

Section C-C

Section D-D

Chandelier Wagenstraat

Connections

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Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Suspension cables - building

Chandelier Wagenstraat

Connections

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Overview connections

3D Impression

Section E-E

Section F-F

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Connection three cables

Chandelier Wagenstraat

Connections

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Overview connections

Structure

Light

3D Impression

Section G-G

Section H-H

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Connection three cables - lighting fixture

Chandelier Wagenstraat

Connections

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Overview connections

Structure

Light

3D Impression

Section G-G

Section H-H

Overview street

Grote Markt/Spui

Connections

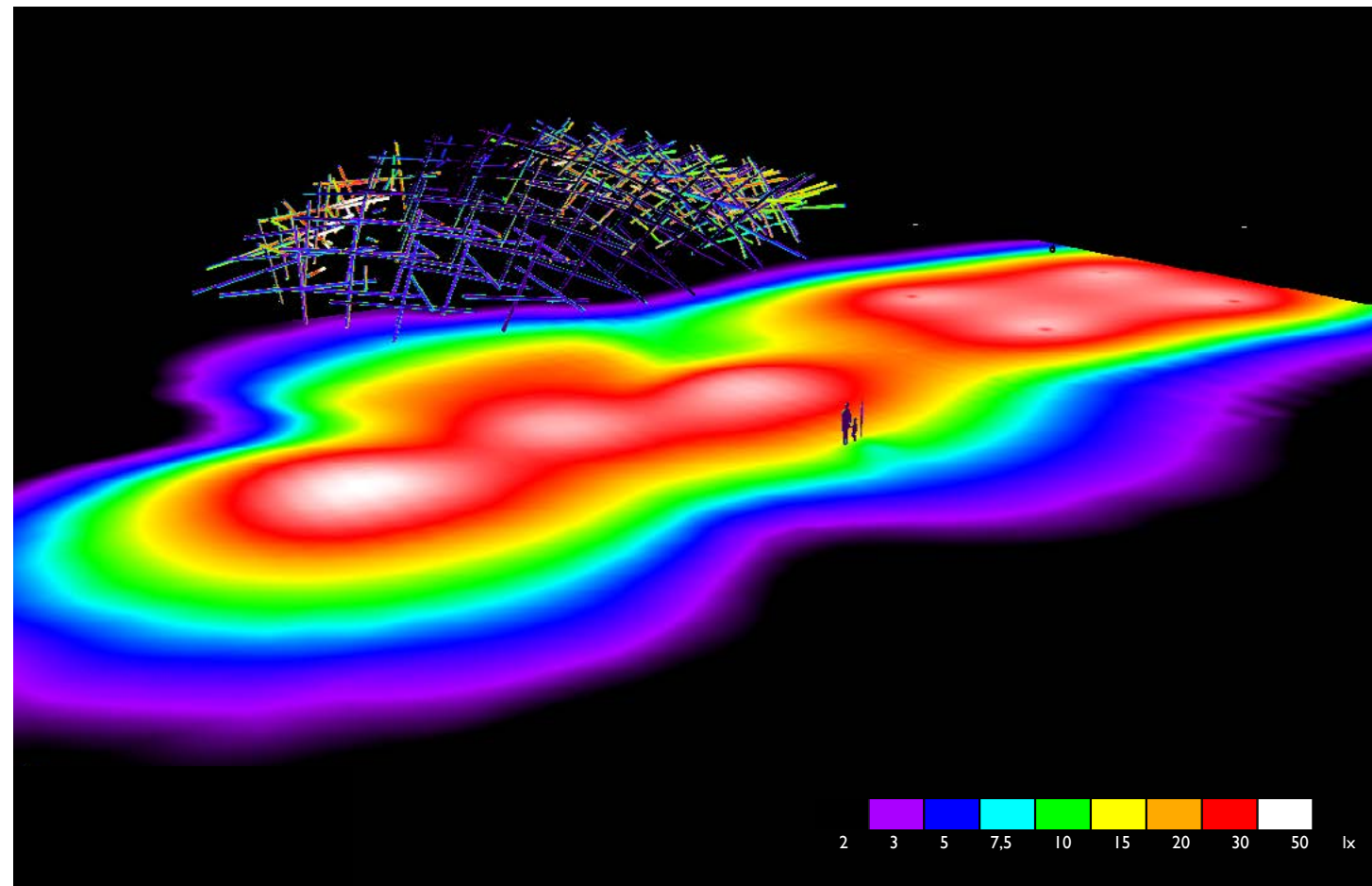
Wagenstraat

Connections

Lighting design

Vertical Elements

Connections



Lighting levels

Chandelier Wagenstraat

Lighting design

The lighting requirements for the Grote Marktstraat are relatively strict. The municipality requested the lighting levels to be an average of 34 lux, and a minimum of 20 lux, with a uniformity of 0,3. The head of maintenance requested for the lighting fixtures not to be movable, so it was decided to completely integrate the fixtures in the structure of the chandeliers. This meant that the direction of the light is completely dependent on the shape of the tensegrity structure, since the light could only be directed in the direction of the struts. An optimization process adapting the shape of the tensegrity to the lighting and vice versa followed to solve the problem, meeting the requirements for most places in the street.

The lighting in the chandeliers is all based on fully controllable LEDs, to create lighting scenarios with different dynamic colour and intensity settings. The functional, white light is kept static, apart from dimming late at night, in order to create the right lighting circumstances for the people in the street.

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

3D model Vertical Elements

Vertical Elements

General information

A ‘vertical element’ for the Grote Marktstraat is a structural system made by assembling tripod modules together in the vertical direction. A tripod is a tensegrity element, built up from three struts, of which the ends are connected to three cables. Various modules are connected to create a linear three dimensional structure.

The height is kept the same for all modules, but the width is scaled to create a fluent shape. The structural shape of the vertical elements is made by connecting twelve modules.

Each vertical element carries two fixtures: one at the top, providing the main functional lighting, and one at the bottom. These fixtures also contribute to the structural shape. Both fixtures produce white light for functional use; the light intensity can be adjusted.

Overview street

Grote Markt/Spui

Connections

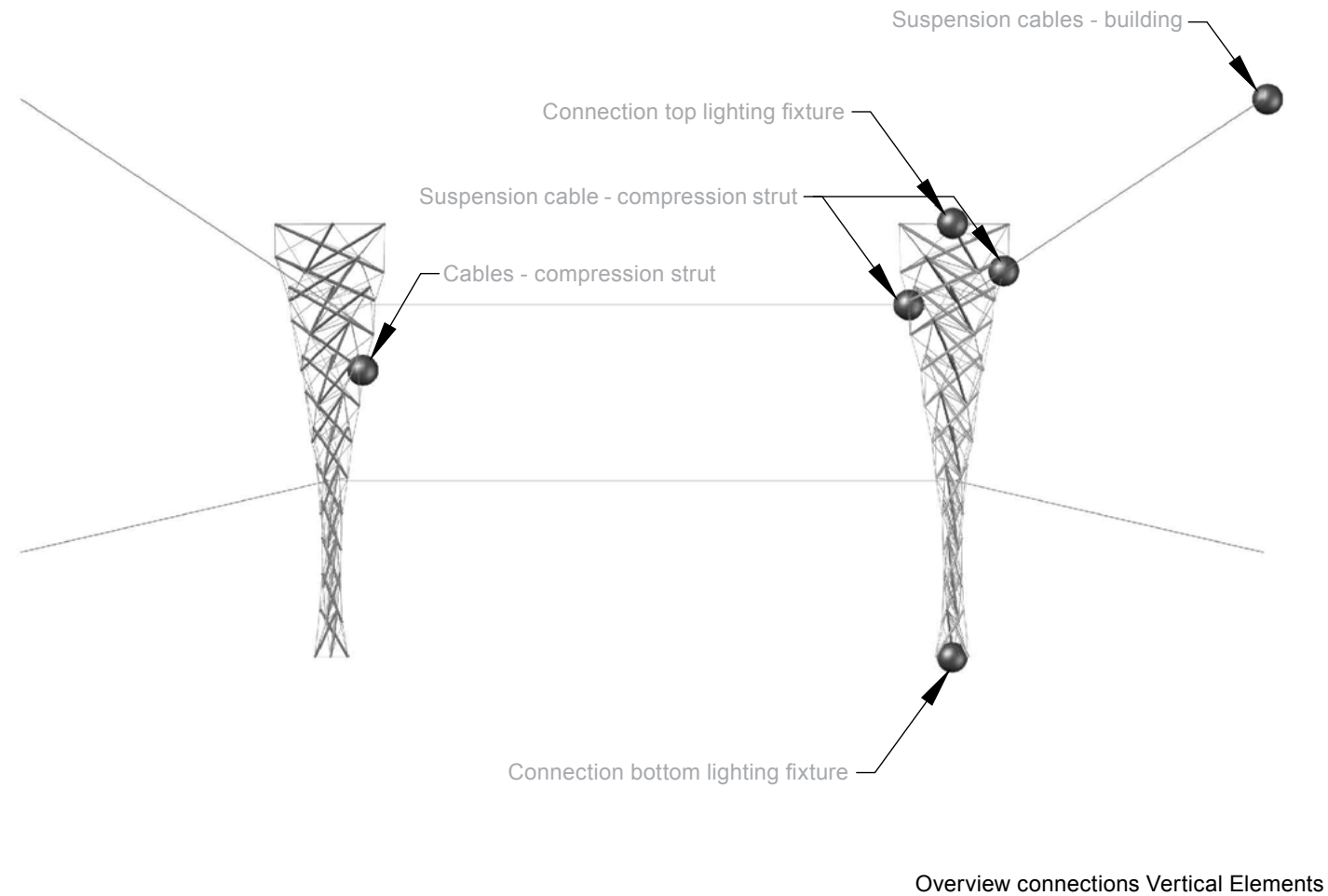
Wagenstraat

Connections

Lighting design

Vertical Elements

Connections



Vertical Elements

Connections

The vertical elements are hung in the street from the surrounding buildings. They are attached in pairs to the top cables, carrying the weight of the structure and to the cables at the bottom of the structure to limit the deformation caused by the wind.

In the typical end details of the vertical elements, seven cables are connected to a strut with a standard casted ring detail. The same detail is used for each node. All cables can easily connect to the node at various angles.

The suspension cables are connected to the struts through a flexible plate. This plate can be placed at different angles to accommodate the various heights of the facades' fixation points.

The fixtures in the vertical elements are attached to the tensegrity by cables.

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Overview connections

3D Impression

Section A-A

Section B-B

Cables - compression strut

Vertical Elements

Connections

The vertical elements are hung in the street from the surrounding buildings. They are attached in pairs to the top cables, carrying the weight of the structure and to the cables at the bottom of the structure to limit the deformation caused by the wind.

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Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Vertical Elements

Connections

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The suspension cables are connected to the struts through a flexible plate. This plate can be placed at different angles to accommodate the various heights of the facades' fixation points.

The fixtures in the vertical elements are attached to the tensegrity by cables.

Suspension cable - compression strut

Overview connections

3D: 1 cable

3D: 2 cables

Section C-C

Section D-D: 1 cable

Section D-D: 2 cables

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Overview connections

3D Impression

Section E-E

Section F-F

Suspension cables - building

Vertical Elements

Connections

The vertical elements are hung in the street from the surrounding buildings. They are attached in pairs to the top cables, carrying the weight of the structure and to the cables at the bottom of the structure to limit the deformation caused by the wind.

In the typical end details of the vertical elements, seven cables are connected to a strut with a standard casted ring detail. The same detail is used for each node. All cables can easily connect to the node at various angles.

The suspension cables are connected to the struts through a flexible plate. This plate can be placed at different angles to accommodate the various heights of the facades' fixation points.

The fixtures in the vertical elements are attached to the tensegrity by cables.

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Overview connections

3D Impression

Section G-G

Section H-H

Vertical Elements

Connections

The vertical elements are hung in the street from the surrounding buildings. They are attached in pairs to the top cables, carrying the weight of the structure and to the cables at the bottom of the structure to limit the deformation caused by the wind.

In the typical end details of the vertical elements, seven cables are connected to a strut with a standard casted ring detail. The same detail is used for each node. All cables can easily connect to the node at various angles.

The suspension cables are connected to the struts through a flexible plate. This plate can be placed at different angles to accommodate the various heights of the facades' fixation points.

The fixtures in the vertical elements are attached to the tensegrity by cables.

Connection top lighting fixture

Overview street

Grote Markt/Spui

Connections

Wagenstraat

Connections

Lighting design

Vertical Elements

Connections

Overview connections

3D Impression

Section J-J

Section K-K

Connection bottom lighting fixture

Vertical Elements

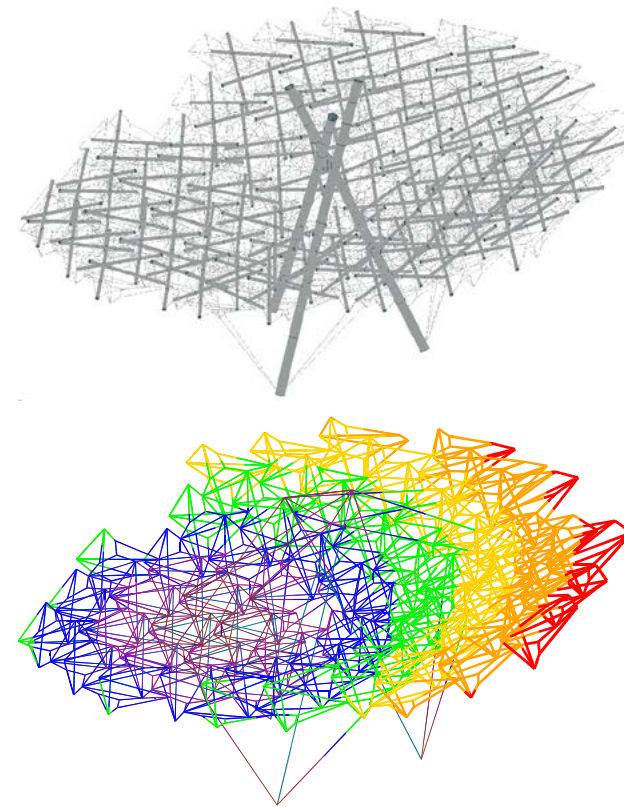
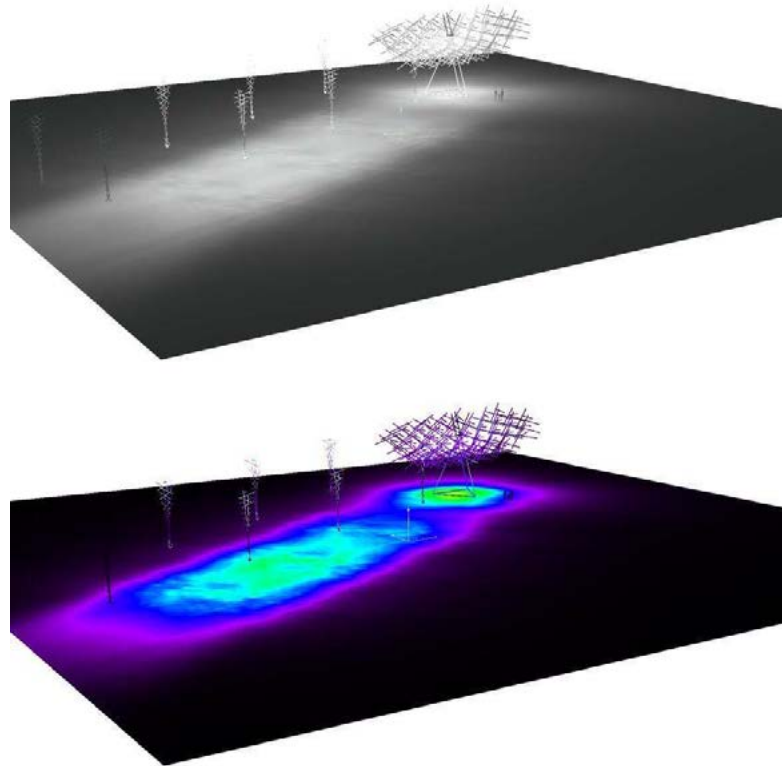
Connections

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Output lighting (left), Displacement due to wind loading (right)

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Arup

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