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Precast Concrete Work in Curved Structures

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Abstract: ***Building component producers face additional hurdles as a result of free form architecture with complicated geometries. A number of famous buildings now include geometrically intricate freeform skins and structures.The skins must be decomposed into manufacturable panels and adequate support structures must be provided.***
This presentation will go over concrete work in curved constructions. A concrete shell, also known as a thin shell concrete structure, is a construction made of a relatively thin shell of concrete that often lacks interior columns and outside buttresses. Concrete shell construction methods are ideal for complex constructions. Curved shapes are naturally robust constructions that allow for the span of large areas without the necessity of internal supports, resulting in an open, unobstructed interior. Because concrete is generally affordable and easily cast into compound curves, using it as a building material cuts both material and construction expenses. The resulting structure could be extremely sturdy and secure. Modern thin concrete shells are composed of thin steel reinforced concrete and often lack any ribs or extra reinforcing structures, relying only on the shell structures themselves.
This paper provides an overview of curved structures and shows how concrete may be utilised as a building material to create curved structures. The purpose of this article is to examine the behaviour of concrete in curved structures that will be used to build load bearing walls.
The study describes methods for producing double-curved precast concrete panels with and without steel reinforcement using flexible moulds.
Concrete is one of the most basic building materials. However, exposed concrete can be used attractively as well. Many architects, including Zaha Hadid and Daniel Libeskind, have employed exposed concrete panels in their designs.
Keywords: Free form structures, precast concrete, shells, panels, formwork, flexible mould, splines, nurbs, pretension.

I. INTRODUCTION OF CONCRETE IN CURVED STRUCTURES (HISTORY)

Once Ar. Zaha Hadid said “people think that the most appropriate building is a rectangle, because that’s typically the best way of using space, but is that to say that landscape is a waste of space? The world is not rectangle.” she was quite aware of how architectural forms “work physiologically upon our senses”

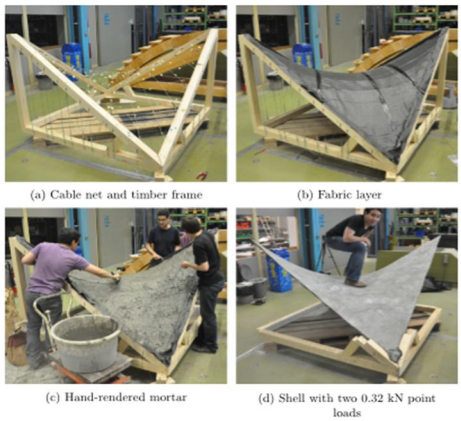


Figure 1. Construction of the first formwork and shell

Engineers such as Felix Candela and EnduardoTorrojo began designing and building exceptionally thin and attractive concrete shell constructions in 1933. Since then, the vast majority of shells have been built by pouring concrete into a wooden formwork. The building of these formwork necessitated a huge staff of skilled craftspeople. Complex double-curved forms were dissected into linear pieces, allowing for the construction of a formwork out of straight boards.

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A. Invention of UHPC (Elimination of Need of Reinforcement)

Inserting a net of steel bars into the casting of a curved panel causes various issues and is also fairly tough.Concrete's maximum compressive strength has increased considerably in recent years. Ultra-high performance concrete (uhpc) is defined as concrete having a compressive strength of 59 between 150 -200 mpa.

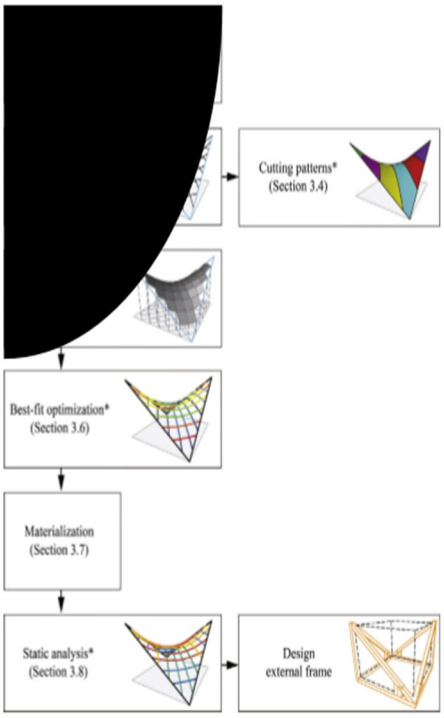


Figure 2. Outline of the computational procedure

Advantages of using uhpc –

1) Offers the construction of light and thin structures.
2) Allows omitting the traditional steel reinforcement.
3) The density of uhpc is very high which makes it durable.
4) The UHPC provides a stunning quality ad finish

B. Design And Construction Of Large Moulds

The enormous mould is constructed to investigate the impacts of scale and material, as well as counter pressure and weight. Fabric is used to make these moulds. These moulds are excellent for concrete casting. A number of requirements must be met by the fabric of choice:

1) The cloth must have a high flexibility so that any wrinkles in the foil can be stretched out.
2) The fabric should be strong enough to withstand the stresses caused by pretension, concrete casting, and ballast application.
3) The fabric should be available in sizes larger than 800 × 800 in order to avoid seams within the mould; and it should be water tight.

II. A TECHNOLOGICAL INNOVATION IN THE METHOD OF MANUFACTRING OF PRECAST CONCRETE PANELS

Researchers from 'to delft, college of civil engineering, proposed a method of manufacturing curved panels utilising an elastic mould surface as a formwork in an effort to make double curved concrete panels more cheaply possible. Their study also examines the behaviour of these moulds using structural mechanics.

This allows for a more adaptable manufacturing approach for curved concrete panels. In this experiment, an elastic material is used to build a flexible mould that can be moulded into the appropriate curved surface using pistons, actuators, pin beds, and so on.

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Figure 3 Double curved panel made by TU delft Students

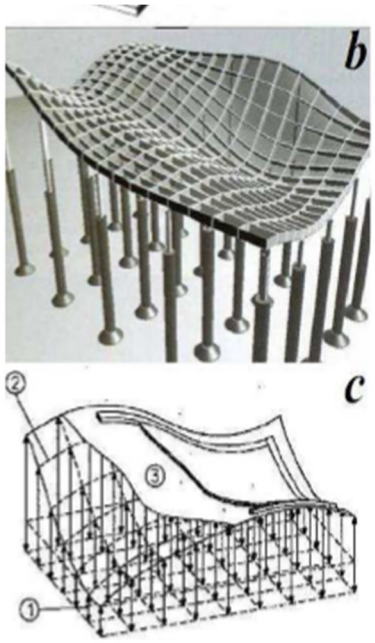


Figure 4 Several sketches of a flexible framework

A. Following Are The Reasons For Using An Elastic Mould As An Intermediate Surface

1) To have a sufficiently smooth surface

2) Due to the vulnerability of the moving parts, it's not recommended to pour concrete directly onto the formwork.

B. Difficulties In Finding The Required Flexibility/ Selection Of The Right Elastic Material

There is a requirement to select the appropriate elastic material with the necessary elastic qualities since too stiff/hard materials make altering the formwork difficult, whilst too flexible materials result in an uneven surface. This can be explained by the prototype created under the supervision of Reitbergen..

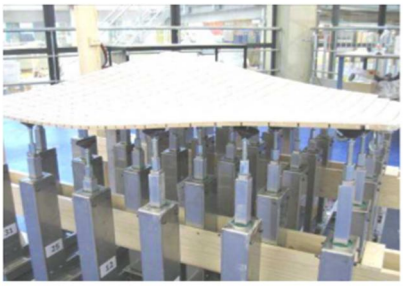


Figure 5. Prototype of a flexible mould built by Rietbergen and vollers

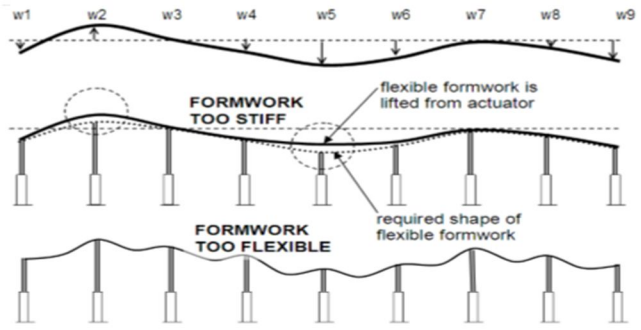


Figure 6 difficulties in finding the required flexibility

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C. Following Are The Factors Which Govern The Shape Of Concrete And The Intermediate Layer

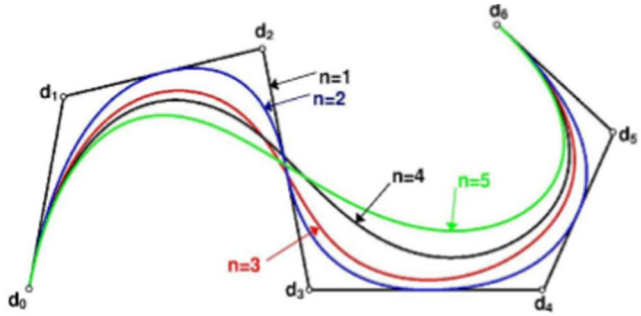


Figure 7 Influence of the degree n in a NURBS curve

1) The key factor determining the shape of the layer is the position of the actuators. • The elasticity of the formwork itself.
2) By interpolating and weighing a number of control points, non-uniform rational b-splines (nurbs) can represent any curvature. It has a direct impact on the formwork's maximum bending stiffness. The formwork should be less stiff if the curve is sharp.

As a result of this experiment, it was concluded that:

a) The flexible mould technology allows for the production of single and double curved precast concrete pieces.
b) In order to control the process, a proper structural mechanics model must be used to anticipate the support reactions and accurate deflection in the deformed shape.
c) The strip mould test equipment shown in this study can be utilised to produce curved elements of 2 x 1 m2 of varying thickness.
d) The thickness of the element does not change greatly during the procedure.
e) By using a 3mm steel reinforcement mesh, the mesh can deform along with the flexible mould and concrete during the process.

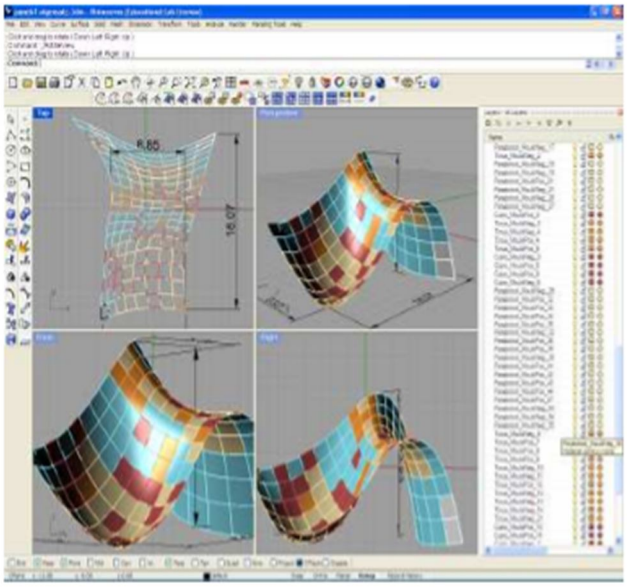


Fig. 13: Example of a NURBS-surface of a virtual building envelope drawn in Rhinoceros

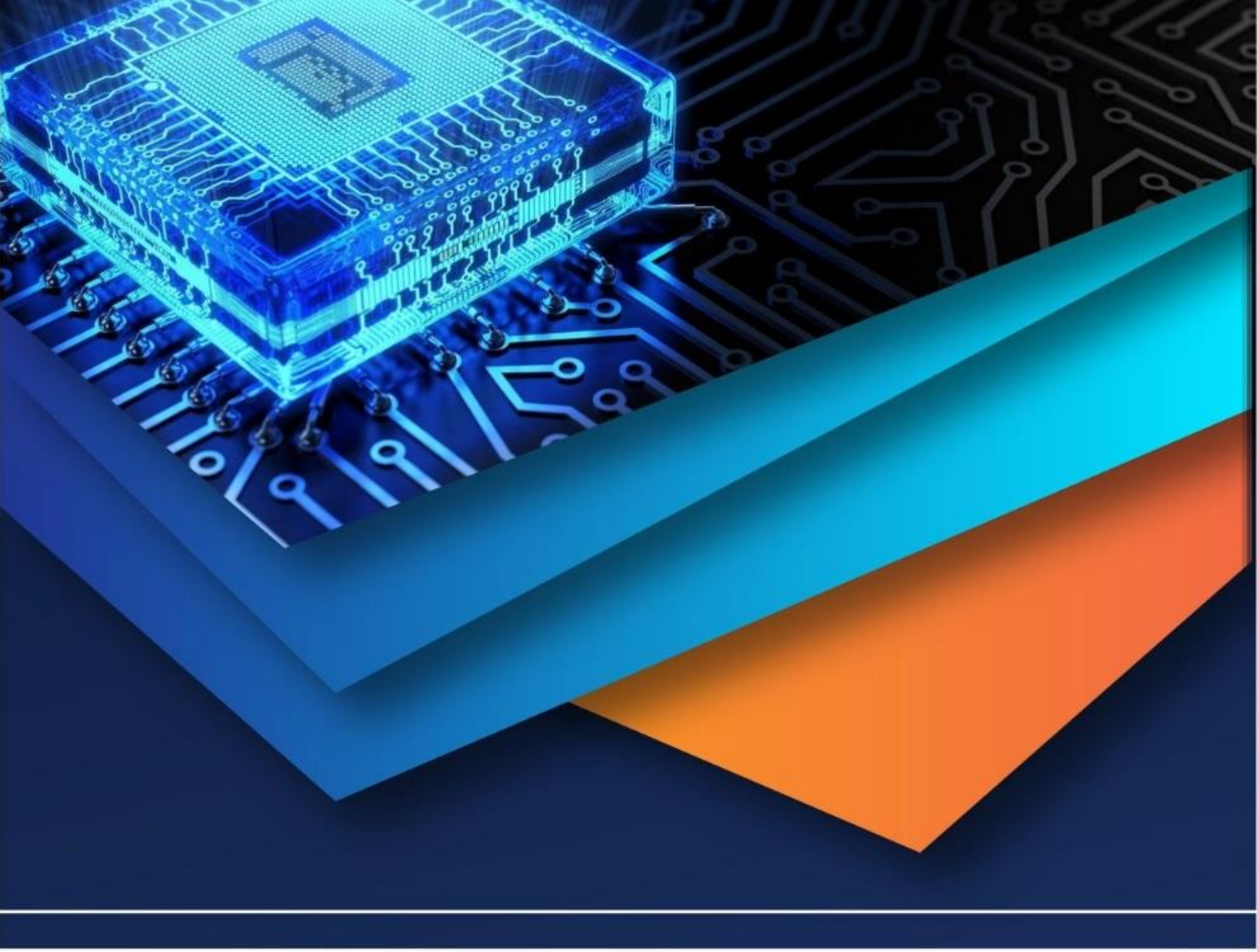
Figure 8.Example of a NURBS- surfave of a virtual building envelops drawn in Rhinoceros

III. CONCLUSION

All of the experiments and investigations presented in this paper lead to the conclusion that it is possible to construct curved structures using concrete panels by using an elastic material for the fabrication of precast concrete panels, on-site timber formwork, or fabric moulds. As a result, there are numerous approaches to achieving the desired curvilinear shape of the concrete. The quality and smoothness of the panels are determined by the quality of the materials, construction management, and expert labour.

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