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Theses of the Ph.D. dissertation

Development of a structural band mesh with standalone elements and an information model

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Preface

Surface models with standalone elements can be found in the early history of building activity from the woven and span huts, through yurts, till contemporary engineering structures.

Building of surface structures with standalone elements has been lately increased dinamically. Amorf gridshell structrures and redefined band mesh structures drew attention of building professionals respectfully. It is no coincidence that the most well-known architectural and structural desing offices (Frei Otto, Ove Arup, Norman Foster, Leonhardt, , Julius Natterer, R. B. Fuller, Happold, etc.) devoted special attention to these structures.

Department of Building of University of Forestry and Timber Industry Sopron started research projects related to gridshell in 1975. Analysis and exploration was lead by Dr. Mihály Kubinszky, Dr. György Somfai and Béla Józsa were involved as researchers from the beginning. Author of this theses joined to this team in 1983. Some gridshell structures were built in Csurgó in 1978, 1981 and 1983, with the collaboration of SEFAG. Results of this behavior of structures lead the author to develop and obtain a patent for band mesh structure.

Summary of this research

Basic study and further development of band mesh structure was initiated because of its structural advantages and unused positive behavior by several aspects.

Analysis and classification of surfaces with standalone elements have great importance in order to understand the logic of structure of these surfaces and to develop new constructions.

Band mesh with standalone elements, developed by the author and fully described in this paper, has a rhombus grid system, which has a significant role in this surface system. Rhombus as a planar shape in which sides are parallel, formed in a plane of the middle line of the surface. The kinematic code system, created by the author, helps to classify the rhombus grid system and understand the logic of structure. Rhombus grid system appears in the following structures: woven and span structures, beam grids, gridshells, band shells, etc

The scope of a curved surface of second degree can be considered by the **kinematic code system**.

Length of the discrete elements hardly exceed the distance oh nodes, so **band mesh with standalone elements,** developed by the author, has countable advantages comparing to gridshell structure , which was a predecessor of band mesh:

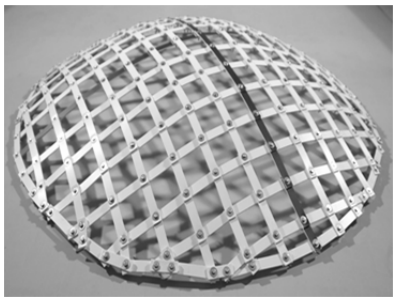
- it is easier to form
- it has higher rigidity in a fixed state
- junctions are considerably less weak caused by borings
- only short elements are needed to build the structure, instead of long ones
- importantly less good quality of material is eligible for the structure
- elements of band mesh system – similarly to beam grids – can be condensed or expanded; further advantage is, that the section of elements can be changed gridpoint by gridpoint
- while studying geometrical behavior of paraboloid of second degree was proved, that it has many preferential feature:
- it is ideal ideal for bearing dead load, since the shape of parabola of second degree approaches catenary to a great

extent, just like the paraboloid surface approaches the chain surface

- despite it is a surface of rotation, the sides of the projected rhombus are colinear; this counts as an advantage by contructing and implementing
- it has a unique feature: despite it is a second degree cirved surface, the standalone elements are torsion-free
- there was proven in the research process, that the deformation of the **band mesh** can be decreased by rigging in a crossing direction, while the strength of it can be increased
- implementation and details of building construction can be solved on the same way as it used at gridshell structure; the small size of element counts as a great benefit

Results and further aims

Regarding to calculations and models it can be stated, that band mesh structure with standalone elements can be used as an economical structure, while a building made from it can be architecturally high standarded and freely formed. Using it for interior desing is promising as well.



Theses #1

A kinematic code system, created by the author, gives the chance to classify diamond meshes

Diamond meshes are such meshes which have standalone segments in two directions. Their opposite sides are parallel in a plane formed by the sides of a planar rhombus.

This kinematic code system for classifying diamond meshes has its importance in understanding the logic of structures of many different diamond meshes such as woven and span structures, beam grids, gridshells, band shells, etc.

This kinematic code system, given in the form of A - B1B2B3 - C1C2C3- - D1D2D3, describes the following

- different structural properties:
- continuity of segments in a node of structure (A)
- bending stiffness and torsional stiffness of elements (B1B2B3),
- possibilities for rotation in a node of structure (C1C2C3), opportunity of move in a node of structure (D1D2D3).

  This code can be used to describe the structural behavior of meshes.

Theses #2

Kinematic analysis and classification of band meshes give the opportunity to describe the degree of curvature of surfaces: degree of curved surface of 1 and 2; and free-formed surface

Band mesh is the subcategory of diamond mesh where the rigidity of elements is significantly bigger in the plane of the shell than to the perpendicular direction to the plane of the mesh.

Kinematic analysis and classification of band meshes has its importance of the view of shell structure's contruction: clearly can be described of structures capable of having the degree of curved surface of 1 and 2; and free-formed surface.

Categories of band meshes:

- band meshes with ordered movements
- band meshes with unordered movements
- band meshes with limited movements
- band meshes with no movements

Theses #3

The band mesh with standalone elements –developed by the author – has significant advantages comparing to gridshell structures

Band mesh with standalone elements is defined as a subcategory of band meshes in which case the length of a single discreet element can exceed the distance between the nearest structural nodes only to a small extent.

The structure demonstrated by the author can be considered as a basically new structure which has several advantages comparing to the widely used gridshell structure

- forming the final shape of the structure is easier, because the structure is significantly softer in the stage of construction before having bracing structures
- the structure works as a rigid shell after having bracing structures
- junctions are considerably less weak due to the borings
- instead of long elements, only short ones are neede for building the structure
- importantly less good quality of material is eligible for the structure

Theses #4

Diamond meshes and especially band meshes with standalone elements in the form of paraboloid of second degree surface have significant advantages

Shape of paraboloid of second degree surface has geometrical and structural advantages comparing to other second degree surfaces given with closed-forms such as surface of rotation, translation and conoids:

- Second degree curved surface is optimal for constructing shells, because the shape of parabola of second degree approaches catenary (ideal for bearing dead load) to a great extent, just like the paraboloid surface approaches the chain surface.
- It is the only one among the examined second degree curved surfaces which has elements as straight lines in plane projection. This fact provides advantages both in design and in construction.
- It is the only one among the examined second degree curved surfaces which has elements without any torsion.