SMiA

Structural Morphology in Architecture
Structural Morphology in Architecture

RECI PROCAL FRAME STRUCTURES
Structural Morphology in Architecture

RECPROCAL FRAME STRUCTURES

OBJETIVE

Understand the concept of reciprocal structure

Study the morphology

Explore the formation of structural systems with a groupings modules reciprocal
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RECI PRO CAL FR A ME STRUCTURES

TOPICS

1. Definition: reciprocal frame structure
2. Examples in nature
3. Background
4. Morphology
5. Reciprocal modules
6. Groupings of reciprocal modules
7. Details – connections
8. Membranes - reciprocal frame covers
9. Recent Research
1. DEFINITION: Reciprocal frame structure
1. Definition: reciprocal frame structure

• A reciprocal frame is a class of self-supporting structure made of three or more beams and which requires no center support to create roofs, bridges or similar structures. Wikipedia

• The reciprocal frame is a three-dimensional grillage structure mainly used as a roof structure, consisting of mutually supporting sloping beams placed in a closed circuit. Olga Popovic Larsen, Reciprocal Frame Architecture.

• The reciprocal frame is a three-dimensional assembly structure made up of three or more sloping rods in a closed circuit, namely a Reciprocal frame unit. The inner end of each rod rests on and is supported by its adjacent rod.

Signified by the word “reciprocal,” which expresses mutual action or relationship, such closed circuit is obtained as the last rod is placed over the first one in a mutually-supporting manner. At the outer end, the rods are given an external support by a wall, ring beams, or column. Peng Song. Chi-Wing Fu. Nanyang Technological University, Singapore.
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RECIProCAL FRAME STRUCTURES

2. EXAMPLES IN NATURE
2. Examples in nature
2. Examples in nature

The Reciprocal Frame is a simple, efficient, rational and naturally occurring structure.
2. Examples in nature

The Reciprocal Frame is a simple, efficient, rational and naturally occurring structure.
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3. BACKGROUND
3. Background
3. Background

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RECIPROCAL FRAME STRUCTURES

Structures such as the neolithic pit dwelling, Indian tepee or the Hogan dwellings have some similarities to the RF concept. Use the principle of mutually supporting beams.

Indian tepee. Hogan dwelling
3. Background

Mandala geometric: is a spiritual and ritual symbol in Hinduism and Buddhism, representing the Universe.
3. Background

Leonardo Da Vinci establishes the first geometric and structural studies of reciprocity in the year 1500. Da Vinci described in the codex, the construction of a reciprocal bridge with wooden beams.
3. Background

Floors constructed with short timbers - 1890
3. Background

Casa Negre, Sant Joan Despi, Barcelona 1915 - Architect Jose Maria Jujol
3. Background

Casa Negre, Sant Joan Despi, Barcelona 1915 - Architect Jose Maria Jujol
3. Background

Casa Bofarull, Pallaresos, Tarragona 1918 - Architect Jose Maria Jujol
3. Background

Kazuhiro Ishii.
Spinning house 1985
3. Background

Another example of a RF design by Ishii is the Sukiya Yu house where the RF structure. The building in which the RF structure is used is an entertaining space, seven metres in span, named Yu-an. The horizontally overlapping timber RF beams support the wooden dome. To make sure that all the geometry was right the contractors first built 1:5 models of the interlocking joints. When they were sure that the geometry was correct they scaled up the notched timber interlocking beams and constructed the roof.

Kazuhiro Ishii. - Sukiya Yu House - 1990
3. Background

Kazuhiro Ishii. - The Seiwa Bunraku Theater- 1990
RECIProCAL FRAME STRUCTURES

3. Background

Kazuhiro Ishii. - The Seiwa Bunraku Theater- 1990
4. MORPHOLOGY
4. Morphology

Geometric composition - **polygon based**
4. Morphology

Geometric composition - reciprocal vertex
4. Morphology

Geometric composition - elevation angle
4. Morphology

Geometric composition - **inside face of module**
4. Morphology

Geometric composition - bar or panel
4. Morphology

Geometric composition

- reciprocal vertex
- inside face of module
- polygon based
- elevation angle
- bar or panel
4. Morphology

Positive direction

Negative direction

Geometric composition - direction rotation of the vertex
5. RECIPROCAL MODULES
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RECIPIROCAL FRAME STRUCTURES

Modules configuration

Regular modules. Regular polygon base and bars of same length

Regular polygon base and bars of different length

Irregular polygon base and bars of same length

Irregular polygon base and bars of different length
Regular modules. Regular polygon base and bars of same length.
4. Morphology

Regular modules. Regular polygon base and bars of same length.
4. Morphology

Regular modules. Regular polygon base and bars of same length
4. Morphology

Regular modules. Regular polygon base and bars of same length
4. Morphology

Regular modules. Regular polygon base and bars of same length.
6. GROUPINGS OF RECIPROCAL MODULES
6. Groupings of reciprocal modules - Regular modules
6. Groupings of reciprocal modules - Regular modules
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RECIPROCAL FRAME STRUCTURES

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6. Groupings of reciprocal modules - Regular modules
6. Groupings of reciprocal modules - Regular modules - Arches
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6. Groupings of reciprocal modules - Regular modules - Arches
6. Groupings of reciprocal modules
6. Groupings of reciprocal modules
6. Groupings of reciprocal modules - Regular modules - Panels
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RECI PROCA L FR ME STRU C TURES

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6. Groupings of reciprocal modules - Irregular modules
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ETH Zurich, 2009
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RECIPROCAL FRAME STRUCTURES

6. Groupings of reciprocal modules – Irregular modules

Gramazio & Kohler, Architecture and Digital Fabrication
6. Groupings of reciprocal modules – spatial modules

Reciprocal frames on platonic polyhedrons. Eike Schling
Reciprocal frames on platonic polyhedrons.
6. Groupings of reciprocal modules – spatial modules

Reciprocal frames on platonic polyhedrons. Kenneth Snelson
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Reciprocal frames on platonic polyhedrons.
6. Groupings of reciprocal modules – spatial modules

**POLIEDROS RECÍPROCOS**

Son poliedros cuyas caras son reemplazadas por sus semidiagonales, únicas entre sí por un vértice reciproco central. Los extremos de estas semidiagonales definen el polígono base inicial.

Reciprocal frames on platonic polyhedrons.
6. Groupings of reciprocal modules – spatial modules

Reciprocal frames on platonic polyhedrons.
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RECIPROCAL FRAME STRUCTURES

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7. Details - connections
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RECIPIROCAL FRAME STRUCTURES

7. Details - connections
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RECIPROCAL FRAME STRUCTURES

8. MEMBRANES - RECIPROCAL FRAME COVERS
8. Membranes - reciprocal frame covers
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Reciprocal Frame Structures

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KREOD / Chun Qing Li of Pavilion Architecture 2013
8. Membranes - reciprocal frame covers

KREOD / Chun Qing Li of Pavilion Architecture 2013
9. RECENT RESEARCH
The next Wednesday, 12/11/2014 we will assemble the Twist Pavilion.

11:00 near the ETSAV terrace of bar

THANKS FOR YOUR ATTENTION !!