CURRENT RESEARCH JOURNAL OF PEDAGOGICS
(ISSN –2767-3278)
VOLUME 05 ISSUE 02 Pages: 77-81
SJIF IMPACT FACTOR (2022: 6. 013) (2023: 7. 266) (2024: 8.125)
OCLC – 1242041055
Publisher: Master Journals

Journal Website: https://masterjournals.com/index.php/crjp

Research Article

FORMATION OF DISCRETE FRAMEWORKS OF LATTICE STRUCTURES WITH HEXAGONAL CELLS IN PLAN

Submission Date: February 19, 2024, **Accepted Date:** February 24, 2024,
Published Date: February 29, 2024
Crossref doi: https://doi.org/10.37547/pedagogics-crjp-05-02-13

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ABSTRACT

The article highlights the question of static-geometric modeling of a discrete framework of two-belt lattice constructions is considered. In addition, a static system equilibrium model is presented.

KEYWORDS

Modeling, two-belt, structure, system, design.

INTRODUCTION

Lattice constructions with double belts are among the least expensive kinds of coverings. Because the material of the supporting structures functions exclusively in tension and their (the structures) the bearing capacity is fully used.

The two-belt lattice structure is a geometrically invariable/unchangeable system. It consists of specially arranged rods connected at nodes. The presence of two belts (distanced from each other by the distance required by the calculation) provides the necessary rigidity of the structure, and, as a consequence, the load-bearing capacity.

Static-geometric approach to modeling two-belt lattice structures can be implemented using various physical models [1]. One of them is the stretched (compressed) network model.

The equilibrium condition for a node in an arbitrary network has the following form:

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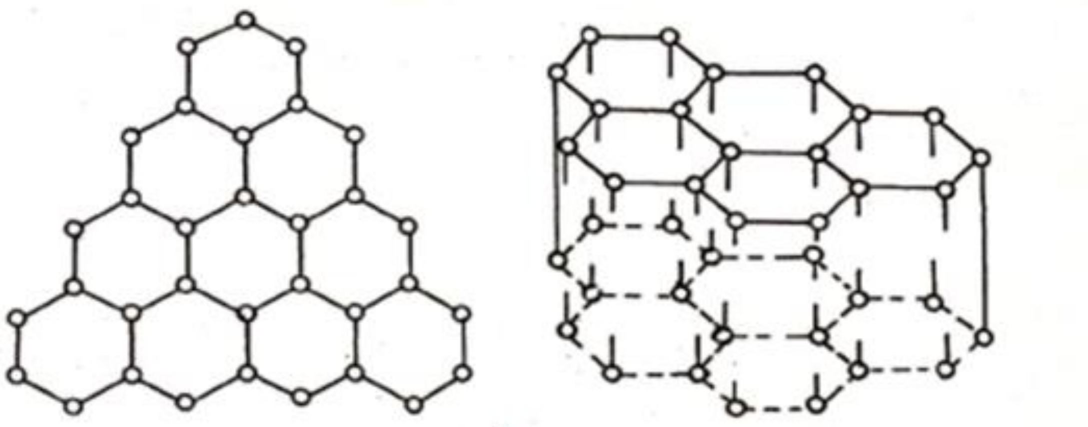
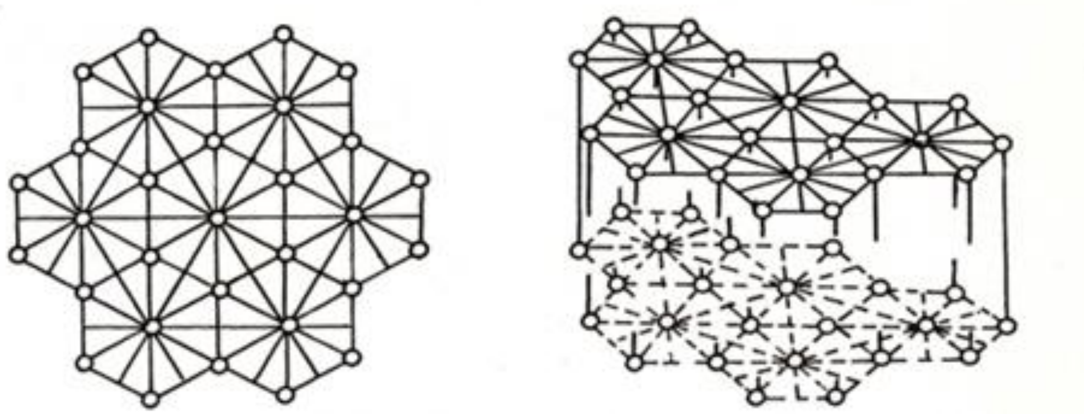


a)



b)

Figure 1.

Plans and visual representations of two-belt lattice structures

$$Q_i + \sum_{p=1}^{n} Rp = 0, \qquad (1)$$

When using stretched networks to model apparatus the magnitude of the force is assumed to be proportional to the length of the connection. In this case, the geometric interpretation of (1) has the following form:

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$$\begin{cases} \sum_{t=1}^{n} k\left(u_i^b - u_0^b\right) + \sum_{t=1}^{n} P_{i,j}^{\;b} + Q_{i,j}^{\;b} = 0, \\ \sum_{t=1}^{n} k\left(u_i^{\text{H}} - u_0^{\text{H}}\right) + \sum_{t=1}^{n} P_{i,j}^{\;\text{H}} + Q_{i,j}^{\;\text{H}} = 0, \end{cases} \qquad (2)$$

where u_0- coordinates of the central nodes of the calculated/design star;

u_I- coordinates of adjacent nodes with the center (i=1,2,3,..)

i,j - serial numbers of reference lines of star nodes;

U - generalized designation of coordinate x, y , z .

System of equations (2) for each pair of corresponding nodes splits into three systems (according to the number of coordinates).

Based on type III networks (Figure 1.a), the systems have the following form:

$$\begin{cases} x_{i\pm1,j}^{\text{B}} + x_{i,j\pm1}^{\text{B}} + x_{i\pm1,j\pm1}^{\text{B}} - \\ -3x_{i,j}^{\text{B}} + k\sum_{t=1}^{n} P_{x,i,j}^{\text{B},t} + kQ_{x,i,j}^{\text{B}} = 0, \\ x_{i\pm1,j}^{\text{H}} + x_{i,j\pm1}^{\text{H}} + x_{i\pm1,j\pm1}^{\text{H}} - \\ -3x_{i,j}^{\text{H}} + k\sum_{t=1}^{n} P_{x,i,j}^{\text{H},t} + kQ_{x,i,j}^{\text{H}} = 0, \end{cases}$$

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$$
\begin{cases}
y^{B}_{i\pm1,j} + y^{B}_{i,j\pm1} + y^{B}_{i\pm1,j\pm1} - \\
-3y^{B}_{i,j} + k\sum_{t=1}^{n} P^{B,t}_{y,i,j} + kQ^{B}_{y,i,j} = 0, \\
y^{H}_{i\pm1,j} + y^{H}_{i,j\pm1} + y^{H}_{i\pm1,j\pm1} - \\
-3y^{H}_{i,j} + k\sum_{t=1}^{n} P^{H,t}_{y,i,j} + kQ^{H}_{y,i,j} = 0,
\end{cases}
\qquad (3)
$$

$$
\begin{cases}
z^{B}_{i\pm1,j} + z^{B}_{i,j\pm1} + z^{B}_{i\pm1,j\pm1} - \\
-3z^{B}_{i,j} + k\sum_{t=1}^{n} P^{B,t}_{z,i,j} + kQ^{B}_{z,i,j} = 0, \\
z^{H}_{i\pm1,j} + z^{H}_{i,j\pm1} + z^{H}_{i\pm1,j\pm1} - \\
-3z^{H}_{i,j} + k\sum_{t=1}^{n} P^{H,t}_{z,i,j} + kQ^{H}_{z,i,j} = 0,
\end{cases}
$$

Sign “+” or “-” in indices for unknown systems (3) is selected depending on the orientation of the hexagonal cell relative to the reference lines of the network nodes.

Compiled for all loose network nodes of a system of equations of the form (3) are solved by known methods.

It should be highlighted that complex two-belt structures can be described by detailed equations with more complex shape. So for the structure shown in Figure 1b, equations (3) have the following form:

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$$\begin{cases} \frac{\sqrt{3}}{2}\left(u^{\text{В}}_{i-1,j+2} + u^{\text{В}}_{i-2,j+1} + u^{\text{В}}_{i-1,j-1} + u^{\text{В}}_{i+1,j-1} + u^{\text{В}}_{i+1,j+1}\right) + u^{\text{В}}_{i+1,j} + \\ +u^{\text{В}}_{i,j+1} + u^{\text{В}}_{i,j-1} + u^{\text{В}}_{i-1,j} + u^{\text{В}}_{i-1,j+1} + u^{\text{В}}_{i+1,j-1} - 2u^{\text{В}}_{i,j}\left(3+\sqrt{3}\right) + \\ +k\sum_{t=1}^{n} P^{\text{В},t}_{i,j} + kQ^{\text{В}}_{i,j} = 0, \qquad (1.2.13) \\ \frac{\sqrt{3}}{2}\left(u^{\text{Н}}_{i-1,j+2} + u^{\text{Н}}_{i-2,j+1} + u^{\text{Н}}_{i-1,j-1} + u^{\text{Н}}_{i+1,j-1} + u^{\text{Н}}_{i+1,j+1}\right) + u^{\text{Н}}_{i+1,j} + \\ +u^{\text{Н}}_{i,j+1} + u^{\text{Н}}_{i,j-1} + u^{\text{Н}}_{i-1,j} + u^{\text{В}}_{i-1,j+1} + u^{\text{Н}}_{i+1,j-1} - 2u^{\text{Н}}_{i,j}\left(3+\sqrt{3}\right) + \\ +k\sum_{t=1}^{n} P^{\text{Н},t}_{i,j} + kQ^{\text{Н}}_{i,j} = 0, \end{cases}$$

The linear relationships that describe the equilibrium equations make the static-geometric approach of building discrete structures easy to use, which is an important advantage of the static-geometric method, and there are many options for influencing the structure's shape.

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