CONTRIBUTION TO SPACE STRUCTURES

The notion of Structure is taking everyday a greater importance in the field of human knowledge, even with immaterial and abstract concepts; we hear, for instance, of: structure of thoughts, structure of mathematics, and so on.

This pervading intrusion of systematic anatomy of form and morphology is reaching now the art of building. In view of its positive and realistic object, the problem should be relevant in strictly mathematical terms, but we prefer an altogether different approach based on the study of elementary structures of crystals and a brief survey of some very curious natural organisms known as "Radiolaria", together with some experimental facts.

When instead of considering purely the geometric relationship of a configuration by itself, but rather in terms of its environment, geometry made a major step towards abstraction and also towards generalization, we strongly believe that the study of space structures should be considered in the same way, that is to say, with a topological mind. Seeing in space is not as we believe merely having a keen sense of the occupation of space by some physical object, but rather being able to grasp the notion of combinational arrangements in view of obtaining certain peculiar conditions.

Inspection of figures 1 to 12, dealing with the geometrical generation of three dimensional networks, is self explanatory and does not need further comment.

The main object is filling space with periodic configurations each enjoying definite physical properties, which with analogy to solid matter can be defined in terms of "isotropy", just like a moment of inertia with respect to its main axis. The whole problem being a distribution of bars such as to allow a minimum weight for a given area. As can be intuitively perceived, this condition is generally fulfilled when a maximum volume of the indeformable unit cell, or combination of indeformable cells, forms regular polyhedra, or combination of regular polyhedra, for a given bar perimeter. This statement is not only valid for parallel reticular planes such as are figured in square and triangular networks, but hold also in the case of rhomboidal unit cell (Fig. 5), but in that case, all bars are no longer equal, the short diagonal being $2\sqrt{3}/3$ times longer than the hexagonal side of the rhomboedron. This configuration appears as being a minimal, in other words makes minimum the internal energy of the system. The bee's hive tri-hedral lid shows a somewhat similar arrangement.
Before considering the practical interest of networks in modern design, let us open the book of Nature and make a brief survey of the unexpected intrusions of space frames in biology. Most of the documents shown come from Haeckel’s ‘Challenger Reports’, and date from 1873. They are related to shells of tiny sea organisms called ‘Radiolarians’ and belonging to the Protista class that is to say, neither plants nor animals. This stupendous vocabulary of forms belongs to the ancient era of creation, where strongly geometrical structures prevailed. In my mind, they should be more than a mere curiosity, but studied carefully as...
highly elaborated pieces of work. From the application in Vierendel’s beam, and the geodetic systems of Mr. Buckminster Fuller type they display all the structural knowledge we have. I have endeavored to show that some peculiar species (Sagenoaria Decranon) fig. 16, is a beautiful example of a triangular network, working together with a thin membrane called velum acting in tension. Most of these skeletons, fig. 17 & 18, are made with hollow siliceous tubes, quite similar to those used in air-craft construction. The reason for such economy of material is certainly a mystery of Nature. As it has been computed, the trihedral lid of the bec’s hive carries only about 2% economy of material on the total. Refinements of this kind surpass by far our present Science of building.

Figure 15

Figure 16

17

18

"H.M.S. CHALLENGER REPORTS"

...In Structural Design.

Three dimensional networks - with their high degree of interconnection - are better suited to the problem of representing relationships between entities. The use of a 3D representation allows for a more intuitive understanding of the connections and their implications. The 3D space provides a more comprehensive view, facilitating easier navigation and analysis of complex systems.

Another advantage of using 3D networks is that they can accommodate a wide range of data types and scales, allowing for a more detailed and nuanced exploration of relationships. The 3D representation also enables the visualization of multiple dimensions simultaneously, providing a more holistic perspective on the data.

In conclusion, the use of 3D networks in structural design offers significant advantages over traditional 2D representations. They provide a more intuitive and comprehensive understanding of complex systems, allowing for better decision-making and problem-solving in a wide range of applications.
Thus far limited budgets have restricted these experiments to timber but the system appears adaptable to other materials as well. The use of steel should be advantageous, since the continuity at the connections could be obtained through welded joints. Caution should be noted regarding secondary moments involved in that particular instance, and the structure should be calculated as a rigid frame.

This solution based on the property of paraboloids of revolution intersected by parallel vertical planes results in a minimum number of bars of different length, together with an unique type of joint. In the near future, when synthetic materials will be available for roofing purposes, propositions of this kind may be worthy of closer investigations.

As a final comment, we will caution designers against considering 3 dimensional networks as capable of solving all problems with unequalled efficiency. Extrapolation in the possibilities of new systems or new materials are always full of risks and dangers. It is certainly true that this technique belongs to a scale exceeding our present need in building, and presently the restrictions lie in the increased labor involved in the connections. In this respect, we will conclude in saying that the choice of a correct modulus for cell unit is likely to decide the economic factor in function of the type of building wanted. This somewhat common place assertion is particularly important in 3 dimensional design.
6

catalogue of objective. Like industry, science, philosophy, and art, as a one or even two year hop, skip
and
calculate of objective. Like industry, science, philosophy, and art, as a one or even two year hop, skip
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for any teacher to indicate to students that they are to get results by running superfluous
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for any teacher to indicate to students that they are to get results by running superfluous
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This is not to say that I depreciate the vigorous and imaginative efforts of people to polish up their

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It is a careless view that our conscious objective manifestations of the new society such as a new

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balance.

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of new era man. New-era man deals in dynamic balance and seeks stability and stability and seeks the appearances

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FRIDAY, MAY 12, 1939, BY R. BUCKMINSTER FULLER

VERIFIED DEPT. OF FINE ARTS, 17 E. 80TH ST., NYC

A PAPER DELIVERED IN A SYMPOSIUM AT N. Y. U.,

ARCHITECTURE FROM THE SCIENTIFIC VIEWPOINT
jump.

General misapprehension exists regarding “science.” First, it is considered by the majority of people to be difficult, ponderous, obscure, annoying. Secondly, science is considered by many harmony loving people to be prosaic, possibly fascinating but nevertheless hard, even cruel and devastating wherefore such schools seek to circumvent the activities of science and grasp only at the fruit that falls from its branches to the ground. I would like to dispel these false notions.

First, let me quote Sir Arthur Eddington’s definition of science which goes somewhat as follows: “Science is simply the sincere attempt to set in order the facts of experience.” It must be remembered however that these sincere attempts must be consistent and universally applied, playing no favorites, leaving nothing out. As a result of such sustained attempts, scientific laws are developed. These laws are in no way arbitrary as are man-made laws of civil conduct about what people may be permitted to do out of the myriad of things they can do. Scientific laws are statements of observation of consistently observed characteristics and behavior patterns. Technology applies science by composing the phenomena of the individual laws in reciprocal arrangement.

For all these reasons the vast activity of science today is often misappraised by the populace who accuse science of arbitrarily inventing and manufacturing gadgets that are unnecessarily disturbing to the status quo. Often the suggestion is heard that a holiday of scientific activity should take place to allow the world to settle down to some nebulous “security.” Inherent in Eddington’s definition is the truth that so long as one is orderly in mind, tolerant, and in command of his faculties of perception, he cannot help but observe and “set in order the facts of his experience,” at least to a relative degree, wherefore a holiday in scientific activity would mean mass mutilation of the perceptive faculties and universal abrogation of integrity. No, we will have no such holiday. Science is simply unearthing the eternally old tapestry of universal dynamics, which have always and for all time been in play and were only obscured from us by our own superstitions and artifices or lack of nervous control and measuring means.

The other night by impulse I reached for a book on my shelves which had been our text book at the Naval Academy 22 years ago. It was the text book on Naval Ordinance and Ballistics—a confidential issue to student officers. I remembered that I had studied it with infinite care, yet had long ago forgotten the specific text. I opened to the first page and read a passage which at that time, pointed as I was at a special engineering art, never occurred to me to possess the universal application which I suddenly found in it after the 22 year interval. To me, now it sounds like sheer poetry, even the perfect love affair. Of course, that is as it should be. Science under the definition I am presenting to you should include all-certainly human beings and their important behavior patterns.

(Quote) “When a force is applied to a body, the effect produced depends upon whether or not the body is free to move. A force applied to a free body produces motion. A force applied to a fixed body produces change of form.

Stress is the mutual action between two bodies, or the parts of one body causing or tending to cause
to be a good citizen we were
love of that instrument of world-glory. We were taught that in order to be a good citizen we were
per family were asked to think in the same tradition of peoples who were developed on far and passed
tradition must rapidly vanish. We, who in America have approximately an aqua, a telephone, and a radio
issue. This Royal British Majesty having been at last moved, because he was in „check“, the static balance
consciousness, but it has now outlived its usefulness. We have witnessed how it is preserving in archi-
despite having been brought up by tradition to believe in static balance. That belief, that all the good things
I said earlier that new-era men deals in dynamic balance science and shaping the appearance of living

the Beaux Arts.

research on static academy that is another matter. Listen Condemned! It took us 10 years to get rid of
lecture was excellent as a revolutionary barrier but when it seeks to settle down to become the new eu-
Now this superposition of our design that has come from abroad in the guise of a new „order“ of archi-
Now, they have gone to a certain degree, progressively far afield from good engineering.

job, but because of budgetary limits.

job, but because of budgetary limits.

Sometimes the whole work was allowed, not because the engineer could not have done a finished
would only wrinkle of that little shudder and that cough, etc., what he is articulating might be merely-
be particularly upon it could not refer from anything to conclusions about the unconscious American artist. If the
certainly have to admit that those men who were distanced enough from our American attention to have
You are a little fair on the simplicity of that argument. So am I. It isn’t as simple as that. We
spring product from those excellent productions of such unworthy „architects.“

architects. In fact I am suspicious that what is now being made into „Schools“ of complementary architecture
Good architecture is sense to me is thus often produced by engineers who are unconscious of being

the and obligatory frames of reference.

scientific submission of each problem not only to stress measurements but to the scientific ord, visual, ac-
requires beyond the rough hill, whose lines may be excellent, adequate indication of the problem factors and
the technical difference between both and finished work is that the latter show a fool false finished work. „The technical difference between both and finished work is that the later
in the technical principles involved might warrant adoption. It is simply a manner of the old saying, „never
finished” for they know that industry will not really adopt half-built developments despite the fact
both, we make a distinction between „poor“ and „finished“ work. Good engineers up to turn our a
In experimental development in industrial research of such items as a new amphibious or airplane of
then to move relative to each other: it is any part of causal and opposite actions each of which is called a
But now the economic system that taught us has “renigged.” First, it sent its gold to us which was the essence of its intrinsic property theory (though we are going to put it to work in functional uses), and put its all in mobile fleets, merchant and martial, and finally has uprooted its trademark, “H.R.M. God Emperor,” and exports “it” too, along the northwest spiral lest it (the trademark) be forced to run away. A runaway King in crisis time is not God Sovereign. No God-King, no empire. Vanished the billion producer-customers. A King moved in anticipation of potential “check” is good enough chess, but it may no longer be maintained by steadfast tradition that security lies in immobility. We, here in America, had already found out for ourselves that security lay in mobility, ergo the revolt from reality of 1929 (from reality as dirt) but then of course America was traditionally “gauche” in such matters.

You may say why pick on the King? What has he to do with what you are talking about? I am not picking on George VI as a personality. I am discussing the habits of concept involved in ethical propaganda in maintaining a theoretical economic sovereignty. I speak of the King here as an abstract trademark of the largest business corporation in the world, “The British Empire”—whose anonymous directors see themselves slipping from No. 1 position for the first time in a 1/2 millenium—and who by the shrewdest statecraft existent hope to pull the cat out of the bag even if it means moving the works to America with the possibility of pupeteering with the invisible strings of indirection, not the least important of which are the ethics and aesthetics twins.

The King still is “king” to the salesman of the British trademark and to the Bank of England but to John Doe U.S.A., without analyzing deeply, an awareness will develop that the King Sovereign of the “static” tradition, “A rolling stone gathers no moss” has himself rolled indeed, and may be rolling for some time. God Emperor of a billion people, half of all humans, has anticipately moved. He just “went to the fair to buy some blue ribbons,” but he may find it logically improper to return per schedule and may “tie up the bonnie brown hair” by two way telecast while the “Replus” rushes the kiddies “over” to join them at the Fair (temporarily of course). God King temporizes!!

In the meantime jumping from our intuitive reorientation shock we might well ponder over a possible correlation between the multbillions of emigre dollars now here and the delicately imposed emigre “aesthetic” upon our naive factory articulations of rational survival. Somebody is spending a lot of money.

I have a suspicion that America will lose its inferiority complex that made it dress up its buildings, for 150 years to conform to European tradition now that the King is doing a run around. I hope so. The result will be that spirituality and beauty will be left to expression by life, the only true abstract.

I never thought when I was first working on the Dymaxion house (which was, and still is, only theory and attitude) that it would take a trip of the King of England to America to prove my point—not “mobility” for mobility’s sake but potential mobility for security’s sake. Architecture for the quick, not the dead.

Richard Buckminster Fuller
problems of this kind. It is one of Lomont's tasks to give us the key to many of the geometrical laws. Even if they are revealed, they are not dual; there are a few that are not revealed. This often results in a mass of data which, when disentangled, reveals a mass of facts. Yet when the Lomont experiments are repeated, there is some evidence that the Lomont results bear some relation to the results of other experiments, as we are to indicate in unmodified comparisons.

Radical action of no importance to the London problem. The 3-axis system has developed possibilities for existing cities, its application has been studied for the City of London.

The 3-axis system is based on the Lomont system. The economic advantage is that a horizontal plane between points is controllable. The system can thus be shown to be some 33% more efficient on average. The 3-axis system is therefore selected in preference to the other systems. It can be shown that the division of a plane surface by equilateral triangles is the solution inherent in the 3-axis grid rendering from the overall hexagonal module. How is it possible to accommodate the hexagonal module between points when the hexagonal grid is used?

The hexagonal system usually preferred is hardly better than the 3-axis system in respect of the 3-axis grid. Why the hexagonal module? Why have we been so far focused on the hexagonal grid? Have 3-axis systems been found to be impractical and costly?

Architectural researches on the hexagonal plan are by no means new. Frank Lloyd Wright and other world famed architects have been planning with this theme. But currently our own A structure here have been planned with this theme. But currently our own A structure here...
STRUCTURAL ECONOMY OF HEXAGONAL DESIGN

As a matter of fact we readily believe that with conventional Orthogonal design the potentiality of steel construction has diminished to a standstill. Only a fundamental change in the pattern of building as liable to change the issue, i.e. Less Steel per Square Foot, More Square Feet Carried per Column.

The dismissal of the Orthogonal pattern in building has always far reaching consequences and can only be seriously considered if economies of material and labor are indicated for such a radical change.

Are real economies involved? Can definite figures be given, confirmed by some valid proof?

We must answer; YES—decidedly, conscious as we are that the elementary mathematical tool we use should be developed with greater accuracy and refinement. But indeed advanced mathematics are not necessarily requisite for this very simple problem.

Previous to any formal demonstration (we do not present our argument as a formal demonstration, but rather as a basis for discussion) we believe it far more instructive to give the successive steps that lead us to our conclusion.

In spite of the immense advantage of electric welding and its consequent ‘continuous frame’ characteristics, in spite of highly industrialized components such as light girders or joists, etc., steel structures appear to us as presently lacking that creative ingenuity so largely displayed by builders dealing with prestressed concrete, as if a kind of dead end has been reached in steel usage and performances stabilized into definite or permanent configurations.

NOTE...
the indentation between hexagonal blocks avoiding traffic congestion on main roads.
The 120 degree angle aids visibility without interfering with the structural module.

ANALYSIS OF HEXAGONAL GRID

Roughly described, the main components of any building are peripheral girders receiving the joists which support the flooring elements on which uniform load is superimposed and bearing—these and of course the columns.

The most economical girder weight conditions are obviously reached when the area inscribed by the columns is a square, the load being evenly distributed along the four sides of the square.

If instead of a square area we take a Hexagon supported by six columns (i.e. one at each vertex), for a unit length of beam the floor area becomes 2.6 times the square area.

In fact this very trivial assertion is the base of the Hexagonal Grid idea.

The results of these foregoing observations are given in more mathematical terms in Calculation Sheet A1.

They can be summarized in two paragraphs.

(1)—COMPARING HEXAGON AND SQUARE OF SAME AREA, EQUALLY LOADED AND HAVING EQUAL DEFORMATION, IN HEXAGONAL DESIGN THE ECONOMY OF PERIPHERAL GIRDER IS 50% WITH RESPECT TO THE ORTHOGONAL SYSTEM.

(2)—WITH IDENTICAL WEIGHT AND IDENTICAL DEFORMATION OF PERIPHERAL GIRDER, THE REDUCTION IN NUMBER OF COLUMNS IN HEXAGONAL DESIGN IS 4 TIMES LESS THAN THE NUMBER REQUIRED IN ORTHOGONAL SYSTEM.
### HEXAGONAL FLOORCELL

#### APPROPRIATE WEIGHT COMPUTATION OF A VERTICAL COLUMN IN A HEXAGONAL FLOORCELL

The weights per square foot of the floorcell are determined by selecting the appropriate weights from the chart. The total weight is calculated by adding the weights of the columns and beams.

<table>
<thead>
<tr>
<th>Column Type</th>
<th>Weight (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hexagonal Grid</td>
<td>341 lb</td>
</tr>
<tr>
<td>Square Grid</td>
<td>327 lb</td>
</tr>
</tbody>
</table>

The results may be calculated as follows:

1. Assemble the columns, beams, and girders according to the design specifications.
2. Calculate the total weight of the floorcell by adding the weights of the columns and beams.
3. Ensure that the total weight is within the allowable limits specified by the building code.

### DESCRIPTION OF HEXAFLEX SYSTEM

The Hexaflex system is a unique architectural approach that utilizes hexagonal grid patterns to create a lightweight, yet structurally sound building envelope. The system is characterized by its ability to distribute loads efficiently and achieve a high level of structural integrity with minimal material usage.

1. The hexagonal grid provides a consistent pattern that allows for uniform distribution of loads across the structure.
2. The use of lightweight materials, such as aluminum or carbon fiber, reduces the overall weight without compromising structural integrity.
3. The system's modular design allows for easy adjustment and customization, making it suitable for a wide range of architectural applications.

The Hexaflex system offers an innovative solution for contemporary architecture, combining aesthetic appeal with functional excellence.
**Compared Analysis Between Orthogonal and Hexagonal**

**Distribution of Peripheric Girder**

**Orthogonal** (a)

\[ a) \text{ Identical area - load per girder identical for each} \]

\[
\begin{align*}
\text{Girder: } & 6 \sqrt{3}, \quad \frac{a^{12}}{4} = \frac{a^2}{4} \\
& \frac{a^{12}}{a^2} = \frac{1}{\sqrt{3}} \\
& a_1 = 4 \sqrt{3} = 1.315 \\
\end{align*}
\]  

(1)

On the assumption of same deflection, I being propart.

To \(S\) (Section area), the height of profile being \(c\)

\[
\frac{I_a}{I_b} = \frac{a^3}{a'^3} = 1.315 = 2.28
\]  

(2)

\(a, b\) being the respective weight of girder: \(w = 4a^3c\)

\[
\begin{align*}
\omega_a &= 6a' \omega_b \quad \text{together with} \quad \frac{a}{a'} = I_a / I_b \\
\omega_a &= \frac{2}{3} \frac{a^3}{a'^3} = \frac{2}{3} \frac{a^4}{a'^4} \quad \text{but from (1)} \quad \frac{a'^4}{a^4} = \frac{2}{3} \\
\omega_a &= 2 \omega_b
\end{align*}
\]  

(3)

b) On the assumption of equal weight of girder,

Let us find the value of \(a'\), for an identical load in both floor, and

identical deflection. This condition gives: \(w = w_b\) or

\[
4a'd_a = 6a'd_b \quad \text{and} \quad \frac{a}{a'} = 4a/6a' = 2/3 \frac{a}{a'}
\]

And we have:

\[
\begin{align*}
\frac{I_b}{I_a} &= \frac{3b}{3a} = \frac{a^3}{a'^3} = \frac{2}{3} \frac{a}{a'} \\
3a'^4 &= 2a^4 \\
\frac{a_1}{a_2} &= \sqrt{\frac{2}{3}} = 1.105
\end{align*}
\]  

(4)

The area covered in hexagonal configuration is:

\[
\frac{1}{2} a'^2 \sqrt{3} = \frac{3 \sqrt{3}}{2} \sqrt{2a'^2} = \frac{3 \sqrt{2}}{2} \frac{a^2}{a'^2} = \frac{3 \sqrt{2}}{2} a^2
\]

Let us find the number of columns per area unit:

For an orthogonal floor: \(n_a = 4/a^2\)  
For hexagonal:

\[
\begin{align*}
n_b &= 6/a' \sqrt{3} / 2 \frac{a^2}{a'^2} \\
\frac{n_a}{n_b} &= \frac{2}{2} \times \frac{3 \sqrt{2}}{2} = \sqrt{2}
\end{align*}
\]  

(5)
HEXAFLEX BEAM - CALCULATION OF DEFLECTIONS

Conclusion: The Starr Beam is of no Interest.

\[ V_A = \frac{25}{6} \text{p}_A \quad \text{AND} \quad V_A = \frac{25}{6} \text{p}_A \]

Static gives: \[ 3V_A - 3\text{p}_A = -V_0 \]

\[ V_0 = \frac{3}{2} \]

\[ \text{p}_A = 24\text{EI} \]

\[ \frac{3}{2} \text{p}_A = 24\text{EI} \]

\[ \text{p}_A = \frac{16}{3} \]

\[ M = \frac{4p}{L} \quad \text{AND} \quad M = \frac{4p}{L} \]

The total energy is \[ U = \frac{3}{4} p \text{l} \]

\[ \frac{3}{2} g \]

\[ \frac{g}{2} \]

\[ \text{CONCLUSION:} \quad \text{THE STARR BEAM IS OF NO INTEREST} \]

\[ V_X = \frac{3}{2} p \]

\[ \text{AND} \]

\[ \frac{3}{2} g \]

\[ \frac{g}{2} \]

\[ \text{COMPARISON ANALYSIS WITH A NUESENTIAL BEAM ON 2 SUPPORTS} \]

\[ \text{THUS} \]

\[ \frac{q}{a} = \frac{q}{a} \]

\[ + \]

\[ \frac{q}{a} = \frac{q}{a} \]

\[ \text{EYX MAX} \]

\[ x = a \]

\[ \text{AND} \]

\[ \text{FOR} \]

\[ \frac{dq}{dx} = \frac{q}{a} \]

\[ \text{EYX} \]

\[ x = a \]

\[ \text{AND} \]

\[ \text{LENGTH} \]

\[ \text{DEFLECTION} \]

\[ \text{TOTAL LOAD ON BEAM} \]

\[ \text{STARR - TRIANGLE BEAM - UNIFORM LOAD} \]

\[ V = \frac{25}{6} \text{p}_A \]

\[ \text{AND} \]

\[ \frac{25}{6} \text{p}_A \]

\[ \text{WITH} \]

\[ \text{AND} \]

\[ \text{TOTAL LOAD ON BEAM} \]

\[ \text{DEFLECTION} \]

\[ \text{STARR - TRIANGLE BEAM - UNIFORM LOAD} \]
Hexasflex Beam: Calculation of Stresses and Section Area

\[ \text{LENGTH: CENTIMETER, FORCE: KILO} \]

\[ \tan \theta = \frac{40}{543} = 0.0736 \]

\[ p = \frac{Q_0}{a} = \frac{6400}{543} = 11.8 \] (Assumed load: 500 K⁺ per sq. meter.)

\[ N_{OB} = \frac{48}{25} p_a \]

\[ N_{AB} = \frac{N_{OB}}{2 \sin \theta} = \frac{48 p_a}{3.68} = 13.1 \text{ p.a.} \]

\[ N_{OB} = \frac{48 \times 11.8 \times 543}{25} = 12,350 \text{ K⁺} \]

\[ N_{AB} = 13.1 \times 11.8 \times 543 = 84,000 \text{ K⁺} \]

\[ N_{AO} = N_{AB} = 13.1 \text{ K⁺} \]

\[ \sigma_{AB} = \frac{N_{AO}}{I/V} = \frac{84,000}{119.6} = 58.3 \text{ cm²} \]

Taking for \( AO: 26 \text{ HN} \quad \eta = 119.6 \text{ cm²} \quad \text{Weight} = 94 \text{K/M} \]

And \( I/V = 119.6 \text{ cm³} \quad \text{WE HAVE FOR TOTAL STRESS IN OA:} \]

\[ \sigma = \frac{N_{AO}}{I/V} = \frac{84,000}{119.6} + \frac{435,000}{119.6} = 10.79 \text{ K⁺/cm²} \]

**Note:** The pretension of tie is adjusted to equalize sag of peripheral girders.

Peripheral Girder: Assuming built in ends and continuity:

\[ \delta = \frac{QL^3}{384EI} \quad \text{where we make} \quad \delta = 7/500 \times 543 = 1.09 \text{ cm} \]

\[ I = \frac{6.4 \times 5.43^3 \times 10^3}{384 \times 2 \times 10^6} = 1230 \text{ cm}^4 \]

Taking HE 15 - Weight: 26 K⁺/M

Columns, from tables: HN 12 - 26 K⁺/M

CONCLUSION

Whether these substantial economies can be obtained in practice and whether they tend to outline a revolutionary trend in our present building routines, indeed, we do not know.

The proposed shift to a Hexagonal Grid undoubtedly would so modify deep rooted habits and psychological behavior, that presently no valuable prophecy can be made.

Consider for instance the stately reception room vistas characteristic of the seventeenth century Architecture; consider also the omnipotent dogma of facades, these considerations now utterly inconsequent to the new Isotropic configurations, governed by the inexorable laws of economy.

As already mentioned we are intellectually and intuitively convinced that this economy is not fictitious and equally convinced that such economy is consistent with valuable conveniences such as increased flexibility in inner arrangements, and perhaps far more functional adaptability than occurs in the conventional patterns.

R. Le Ricolais
Paris, France
February, 1953
A Cold Party Badge, which only the Party members of the Party had.

The city of Dessau decided to close the Bauhaus. They stopped us and they said, "You have to go."

But now we talk about what really happened in the end.

It was then I knew it was absolutely hopeless. It was a political movement. It had nothing to do with Kandinsky's work, and I had a heck of a time, you know, with Kandinsky. Kandinsky had his constructions of old pictures, and I had a heck of a time, you know, with Kandinsky. Kandinsky had his constructions of old pictures.

There was only about twenty that had these gold medals. He was one of these men. And he came, and we gave them to you. And then they came. It was a long talk. There was one man: his name was Schiule-Nammburg, and he liked to say here: I'd like to see these people. And I said, "No, I'd like to give you a vacation." And I asked, "Are you satisfied with the Bauhaus?" And I said, "No, I'd like to give you a vacation." And I asked, "Are you satisfied with the Bauhaus?"

1933 I closed the Bauhaus. Maybe that is interesting to you. In 1933 I closed the Bauhaus. Maybe that is interesting to you.

I became director of the Bauhaus only because the group came one morning with the mayor of Dessau.

THE END OF THE BAUHAUS.
The mayor, who loved the Bauhaus and wanted to help us, said, "Take all the machinery, all the weaving looms, and just leave."

So I rented a factory in Berlin. I did that on my own. It cost me 27,000 marks for three years. It cost 9,000 marks a year. That was a lot of money in Germany, nothing in America. So I rented this factory that was terrible, black. We started to work—all of us—every student. Many Americans who were with us will remember that we cleaned it all up and painted everything white. This was a solid, simple factory painted clean, wonderful, you know. And just on the outside, on the street, there was a broken down wooden fence, closed. You couldn't see the building. And I can assure you there were a lot of people when they came there and they saw this fence went home. But the good ones, they came through and stayed. They didn't care about the fence. We had a wonderful group of students.

One morning, I had to come from Berlin in the streetcar and walk a little, and I had to pass over the bridge from which you could see our building, I nearly died. It was so wrong. Our wonderful building was surrounded by Gestapo—black uniforms, with bayonets. It was really surrounded. I ran to be there. And a sentry said, "Stop here." I said, "What? This is my factory. I rented it. I have a right to see it."

"You are the owner? Come in." He knew I never would come out if they didn't want me to. Then I went and talked to the officer. I said, "I am the director of this school," and he said, "Oh, come in," and we talked some more and he said, "You know there was an affair against the mayor of Dessau and we are just investigating the documents of the founding of the Bauhaus." I said, "Come in." I called all the people and said, "Open everything for inspection, open everything." I was certain there was nothing there that could be misinterpreted.

The investigation took hours. In the end the Gestapo became so tired and hungry that they called their headquarters and said, "What should we do? Should we work here forever? We are hungry and so on." And they were told, "Lock it and forget it."

Then I called up Alfred Rosenberg.*** He was the party philosopher of the Nazis culture, and he was the head of the movement. It was called Bund Deutsche Culture. I called him up and said, "I want to talk with you." He said, "I am very busy."

"I understand that, but even so, at any time you tell me I will be there."

"Could you be here at eleven o'clock tonight?"

"Certainly."

My friends, Hilberseimer and Lilly Reich and some other people said, "You will not be so stupid as to go there at eleven o'clock?" They were afraid, you know, that they would just kill me or do something. "I am not afraid. I have nothing. I'd like to talk with this man."

So I went that night and we really talked, you know, for an hour. And my friends, Hilberseimer and Lilly Reich were sitting across the street in a cafe window so they could see when I came out, if alone, or under guards, or what.

I told Rosenberg the Gestapo had closed the Bauhaus and I wanted to have it open again. I said, "You know, the Bauhaus has a certain idea and I think that it is important. It has nothing to do with politics or anything. It has something to do with technology." And then for the first time he told me about himself. He said, "I am a trained architect from the Baltic states, from Riga." He had a diploma as an architect from Riga. I said, "Then we certainly will understand each other." And he said, "Never! What do you expect me to do? You know the Bauhaus is supported by forces that are fighting our forces. It is one army against another, only in the spiritual field." And I said, "No, I really don't think it is like that." And he said, "Why

*** Author of Der Mythus Des XX. Jahraunderts: bible of Nazi philosophy
He was there. But the talk about it is obscure nonsense. They don’t know. I know. That is the real end of the Baunhaus. Nobody else knows it. You know. We know. Alfred knows it. And was delighted. Then we stopped. I had worked on it for this moment. It was the reason I ordered champagne. Everybody accepted it. But the faculty has decided to close it.

"Thank you very much for the permission to open the school again," I said. "I hope you will agree. And now I make a proposition, and I hope you will agree. I want to open the school again. And now, I hope you will agree. I want to open the school again. And now, I hope you will agree. I want to open the school again. And now, I hope you will agree. I want to open the school again. And now, I hope you will agree. I want to open the school again. And now, I hope you will agree. I want to open the school again.

"That is wonderful," I said. "There is wonderful." I said. "There is wonderful." I said.

"I still get a letter saying we could open the Baunhaus again. When I got this letter, I called Lillie."

"What is wonderful," I said. "There is wonderful." I said. "There is wonderful." I said.

"I feel it is OK. With us. But it is wonderful." We open the Baunhaus."

"What is wonderful," I said. "There is wonderful." I said. "There is wonderful." I said.

"I make all the decisions about that. And so on. But we don’t know what is wonderful." We open the Baunhaus.

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The School of Design requires that every student during the summer vacation after the Sophomore Year do a research project on “Regional Architecture.” This Regional Research project is intended to instill in the student an interest and respect for historic buildings of his native region. Our task is an extension of that of the Historic American Building Survey, from which the following information has been obtained:

“It is the purpose of the Historic American Building Survey to study, measure, and draw up the plans, elevations and details of the important antique buildings of the United States. Our architectural heritage of buildings from the last four centuries diminishes at an alarming rate... It is the responsibility of the American people that if the great number of our antique buildings must disappear through economic causes, they should not pass away unrecorded.

“The general scope of the Historic American Building Survey contemplates measuring and recording the complete field of Early American Architecture from the earliest aboriginal structures to the latest buildings of the Greek Revival Period. The date selected as a final terminus is 1860, but this is more or less arbitrary as there may be individual buildings of a later date of a character worth recording, and on the other hand, some buildings erected before this date may not be of a character to make it desirable to record them. Buildings of historic importance, such as birthplaces of statesmen, eminent artists or scientists, will be recorded even though their erection was subsequent to the date set.

“It is intended that the survey shall cover construction of all types, from the smallest utilitarian structures to the largest and most monumental. Barns, bridges, mills, toll houses, jails, fences, markers, and in short structures of every description are to be included so that a complete picture of the culture of the time as reflected in the buildings of the period may be put on record.”

Since there are a number of students from other States enrolled in the School of Design, it is to be expected that this research project will be extended on a national level. Two very good results of the last year’s survey are included.
CATAWBA COUNTY, N. C.
BUNKER HILL COVERED BRIDGE

3rd yr. students
Frank Caldwell and Harold Swift
Way 64-70.
Bridge still stands only a few hundred yards from U. S. Hi-
ghway is no longer in use, but the Bunker Hill Covered
bridge still stands. Carl Gustafson visited by E. Conner.

The original builders of the bridge are Andrew L. Rankin
and the Canady County Historical Association. Learned
from oral testimony of R. F. Conner, grandson of
one of the builders. Mr. Rankin told of construction
bridge. No information is available on the bridge.

In 1783 a rough highway was laid out from Island Ford,
NORTH CAROLINA STATE HOSPITAL,
RALEIGH, N. C.

A bill passed by the Legislature of the State of North Carolina on December 30, 1848, largely through the efforts of Dorothea Lynde Dix, provided for the establishment of a State Hospital for the insane. At the time, North Carolina, save the small territory of Delaware, was the last of the thirteen original states which had no provision for the care and cure of its insane citizens. The passage of the bill to provide funds for the hospital, and the subsequent construction and staffing presented almost insurmountable obstacles, but through the untiring efforts of Dr. Edward C. Fisher, superintendent during the construction years, the hospital received its first patient on March 5, 1856.

Ted Peters
5th yr. student
In order for this system to be useful, it must be capable of introducing coherence, as well as the greatest
standards as the first successful componentary system of color and themal coordination. Schoenberg knew that
a theoretically attractive sequence of tones. This structure organizes the twelve-tone system which
does not replace the system of composition in which each tone is of equal value and bears a direct relationship
about fifty years ago, the last word Schoenberg realized that the arithmetic-like componentary system could
be the basic structure of any art form is its most important aspect.

One way to learn C major from scratch is to use a growth pattern. For this to be successful, one must be mentally
designed for the task. One way to do this is to use a scale that is related to the frequency of their use.

Order is the most important aspect of music, the aspect which differentiates it from noise. Tonal is second-

These differences, plus a few novel techniques such as rhythm modulation, dissonance, chromaticism, ex-

non, have taken place.

Kraft, in harmony. Both melody and modulation of chords are changes in chordal modula-

within musical grid. The grid is often described as a game of life by composers to reflect their

invention of tonality. The past several decades has resulted in a stronger current by composers to reflect their

formal and emotional expression. The resultant decrease in the frequency of componentary music in large

of componentary music is the most significant change in the last one hundred and ninety years ago to-

ary, for chords which were considered clunky and "unmusical" a hundred or two hundred years ago to-

These differences, plus a few novel techniques such as rhythm modulation, dissonance, chromaticism, ex-

true, are not only changes in sound but also changes in meaning. When

the music of the future. As a result, music created in "human" or "natural" language for appreciation. The music of

of componentary composers found themselves working in a medium in which the artistic expression had been severely

of his period. First, our componentary music is an outgrowth of the music of the nineteenth century. Music of this period

The peculiarities of music in modern music are analogous to the process of musical development of the past.

also a function of the technical instrumental development of this day. But

Hence, the music of a composer is not to create music. Only a reflection of his time, or

depended upon the discretion of the artist. What is important is that the composer should remain true to

music should be composed of only carefully designed and analyzed, it can be seen that they form

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flexibility, into a composition based upon it. He proposed the use of an arbitrarily arranged sequence of the twelve tones in the octave as a line of reference, rather than the traditional seven tone diatonic scale.

In the twelve tone system, the composer arranges for a particular composition the twelve tones in an arbitrary sequence which, to him, is most suited for the rendering of his artistic ideas. All the thematic and tonal phrases in the composition must be related to the original sequence or to any of the prescribed variations. These variations are affected by inversions, reversals, and transpositions of the original sequence, so that in all, forty eight variations of the first arrangement are possible. Thus, Schonberg constructed a system of musical construction which completely ignores the traditional key system yet retains coherency and expands flexibility. Schonberg’s system is based also on a rigorous polyphonic technique in which each thematic segment is indirectly related to its partner or partners. Here, his music, and the music of two of his more successful students, Alban Berg and Anton Von Webern, is reminiscent of the music of eighteenth century contrapuntal artists.

It is interesting to note the amazing parallel which exists between some of the later music of Bach and that of the aspirants of twelve tone technique. Late in his life Bach devised two works which anticipated twelve tone music by two hundred years. In his Musical Offering which consists of a series of variations in several forms of a given chromatic theme, Bach referred to pure polyphony. A portion of this work is devoted to several canonical variations of the theme. The character of the Bach’s contrapuntal art is anticipatory enough, but in one of the canons, Bach penned an improvisation of the theme for three instruments, each in a different key. The implication here cannot be denied. In the other work, The Art of The Fugue, Bach demonstrated his ability to produce successful fugues from reversals, inversions, and other mutations of an original theme. Here again each thematic phrase becomes independent, yet closely related to the whole. Though Bach’s music was definitely based on the harmonic systems of his day, one cannot help but feel that to him, pure harmony was secondary to thematic structure. Though over two hundred years old Bach’s music is a great deal more novel than most of our contemporary efforts. Incidentally, the later music of Beethoven was also strongly anticipatory of twelve tone techniques especially in his last group of string quartets, and most certainly in his Grosse Fuge, Opus 135.

Schonberg’s origination of twelve tone technique has encouraged the formulation of numerous similar techniques by many of our younger contemporary composers. The general philosophy of these techniques seems to be that the actual substance of the musical material is secondary to the manipulation or modulation of the material. As an outstanding example, John Cage, a contemporary American, has composed a work for twelve radios, where what happens to be on the radio frequency prescribed is secondary to the rhythm, volume, and time intervals inherent in the work. Mathematics plays an important role in these recent innovations, especially in the works of Pierre Boulez and Cage, where relationships are formed between the various musical components (rhythm, time, tone, dynamics) and serial mathematical arrangements. The music becomes a function of the series.

Thus, the twelve tone system and other related techniques stand as a natural step in the evolution of musical development. They are not mere arbitrary formulae for producing “modern” music, but are systems born out of the necessity of integrating thematic and harmonic material in a method consistent to, and expressing, our capabilities. They are not purely theoretical. The most convincing and successful music of the past fifty years has grown from them. Unfortunately, most of these techniques are considered as outrageous and as a hoax on the musical world. Listeners and musicians as well are still so steeped in either tradition or confusion that they do not recognize the real nature of the problem which today confronts musical creation nor the genius which has solved it.

Joseph Costanza
5th Year Student of Architecture
School of Design
North Carolina State College
Visitors to the School of Design for the Spring Term:

GEORGE NELSON (March 30, 31, April 1, 2) Industrial designer of New York City conducting three seminars for students and one public lecture.

ROBERT ROYSTON (March 30 to April 30) Landscape architect of San Francisco (Eckbo, Royston and Williams) conducting a problem with students of landscape architecture and consultant on problem with students in second year architecture.

GEORGE BOAS (April 1 to May 24) Philosopher from Johns Hopkins University conducting a course in Philosophy of Design for fifth year students of the school.

PAUL BURLIN (May 4, 5, 6) Painter now at the School of Fine Arts, Washington University, St. Louis, conducting a series of seminars for the descriptive drawing classes.

WALTER GROPIUS (June 6, 7) Architect to receive the honorary degree of Doctor of Architecture.