I

EXPLORATION OF POTENTIALS OF CORRUGATED BOARD

Diploma Project

Submitted in partial fulfilment of the requirement of the postgraduate diploma in Industrial Design

by

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II

Approval Sheet

Diploma project entitled
'Exploration of potentials of corrugated Board'
by
S.S. Katrekar is approved for the postgraduate diploma in Industrial Design.

Guide - U.A. Athavale

Chairman - 8/1.79

Examiners - 8.1.1979

Acknowledgements

My acknowledgement to my Guide Shri U.A. Athavankar for the useful guidance he rendered throughout this project work.

ABSTRACT

Chapter 1 Introduction

This chapter contains problem statement that defines the problem and explains in short why is it necessary to explore the potentials of corrugated board. It also deals with the scope of the problem and aim of the project.

Chapter 2 Data of corrugated board

This chapter on general data of corrugated board gives an idea of the nature of the material and the existing processes possible.

Chapter 3 Approach to the problem

This chapter explains how and why the approach differs from that of designing a specific product. It also explains result of this approach.

Chapter 4 Material understanding

This chapter deals with the preliminary experiments by different processes that

show a general behaviour of the material under particular situation and also shows how the properties can be built.

Chapter 5 Concept development and possible end uses

It deals with further development of properties and the end uses based on these concepts.

Chapter 6 Summary

It gives general summary of the project with conclusions of the experiments.

Annexure

Bibliography

CONTENTS

Chapter 1 INTRODUCTION

1.1 Problem Statement

The title 'Exploration of potentials of corrugated board' can be defined as the ways of building up its properties that the variety of end uses might demand.

The property of the ultimate product is the combined result of the basic property of the material itself and the property achieved by cutting, bending, folding, taping etc. Later area is where contributions can be made. Taking into consideration the existing limited use and the limited ways in which corrugated board is being used, it is felt that the new methods of using the material will widen the range of end uses and suggest more economic solutions to the present methods.

The aim of the project is to discover new ways in which the corrugated can be used. The new way of using will in turn suggest different end uses.

Existing data on corrugated board is assumed since it was not possible to make experiments to generate such data.

1.2 Scope of the problem

Idea of this project is not to design the specific product as such but to build up properties which will be useful while designing a specific product in corrugated board. Failures of experiments have also added to more and more information about the material behaviour. Whenever experiments have succeeded in building up a particular property, sample applications are suggested to convincingly prove that the concept works. The sample applications will not be the only applications but the property evolved may be applied for any other similar situation. The properties evolved can be used in isolation or in combination which will give still more different properties that may suggest different end uses.

The methods of using corrugated board will not only be useful for the applications for products but will also suggest a new and different direction of thinking which will help further exploration of the material.

Chapter 2 GENERAL DATA ON CORRUGATED BOARD

2.1 Nature of the material

Ultimate strength of the corrugated board as available in the market is determined by the following features :

1. Flute characteristics
2. Physical strength of the components like corrugating medium, liner and adhesives
3. Constructional qualities

Basically the material is light weight as compared to solid cardboard or plywood of the same caliper. The weight and cost depends upon the plies and grammage of paper used. Corrugated board is more stronger in both directions if cross fluting is used. The material is easy to process. Possible processes are as follows :

1. Slitting, cutting, slotting
2. Taping, gluing, stitching, stapling
3. Creasing and scoring.

If coated with plastic it improves its resistance to water and if lined with a cloth it improves its scratch and puncture resistance.

Material due to its structure (corrugations) has got good shock absorptivity which increases as the flute height increases. Corrugated board does not rust, corrode but becomes brittle under hot and dry conditions. It absorbs moisture in humid atmosphere. The shelf life of the material is short.

Chapter 3 APPROACH TO THE PROBLEM

Approach to the problem is different than that of designing a specific product where basic function of the product is known and the product is developed to satisfy the basic function. Whereas in this project the efforts are made to explore the material without any specific product in mind but with an idea of achieving a particular property.

This approach was necessary to avoid a mental block which would have prevented the material from being explored truely.

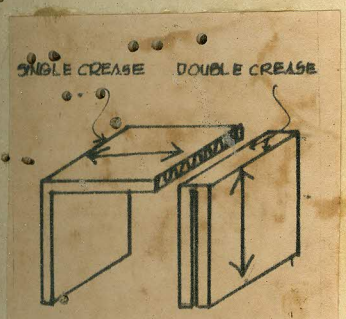
Every experiment generated new information about the material behaviour under different situations. This information was useful for further exploration.

Chapter 4 and 5 explain the ways of using the material which generate different properties that are useful for different end uses.

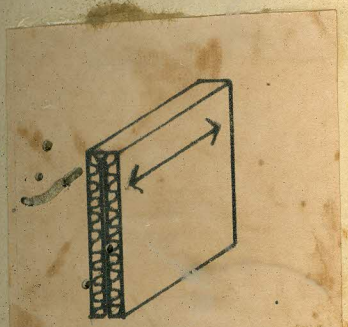
Chapter 4 MATERIAL UNDERSTANDING

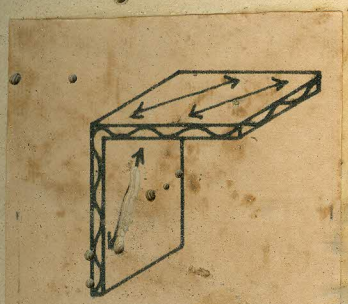
4.1. Creasing and folding

4.1.1 Single fold



CORRUGATIONS AT RIGHT-ANGLE TO THE FOLD LINES.


CORRUGATIONS ALONG THE FOLD LINES.


CORRUGATIONS AT INCLINATION TO THE FOLD LINE.

Studies were made to find out the effect of folding the corrugated board N.F. 3Ply with respect to the different directions of flute. The results were as follows :

<u>Corrugations at right angle to the fold line</u>

In this situation it is possible to bend the corrugated board upto approximately 90°. The outer edge gets damaged if it goes beyond this folding limit. It is desirable to have parallel fold lines close to each other to bend the corrugated board upto 180° without damaging the outer edge.

<u>Corrugations along the fold line</u>

This makes it possible to bend the corrugated board upto 180° without damaging the outer edge. This can be achieved without a crease line. It is not desirable to have a creasing operation along the flute directions as the liners get damaged during the creasing operation.

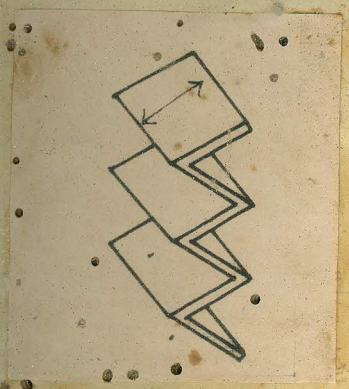
<u>Corrugations at an inclination to the foldline</u>

The effect observed at the outward bend is

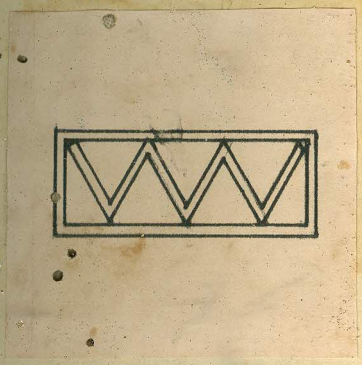
similar to the situation where the corrugations are at right angle to the fold line.

In all the situations discussed above, the situation where the corrugations are at right angle to the fold line was found to be most strong and fairly satisfactory and is at present being used in corrugated board box manufacturing industries.

4.1.2 Parallel creasing and folding



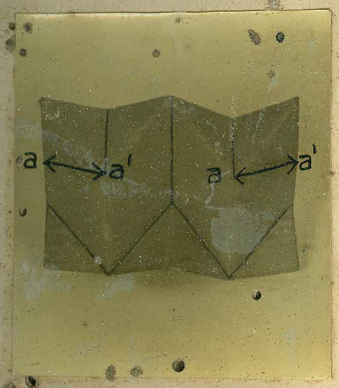
sketch



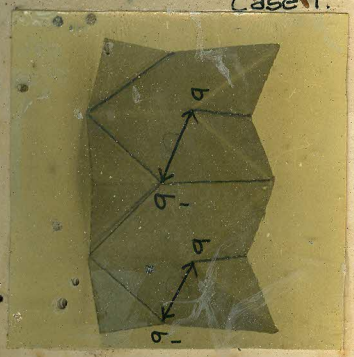
It is a further development of 4.1.1. Resulting structure by giving folds in alternate directions gives properties of folded plate structure which can be used under sustained load conditions when the ends are rigidly fixed. The structure is strong along the fold lines.

The structure is strong only if the direction of corrugations are at right angle to the fold lines. But the structure is weak if the corrugations are parallel to the foldlines.

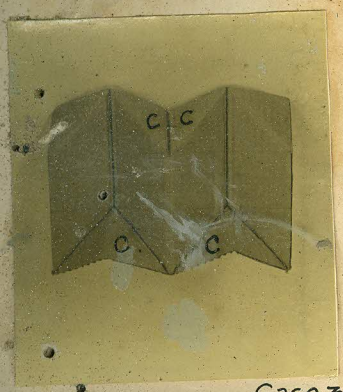
4.1.3 Zigzag creasing and folding



Case 1.



Case 2



Case 3.

Corrugated board was creased and folded as shown in the photographs. The direction of flutes in each case was different as indicated here. Following results were observed :

Case 1 : Corrugations at right angle to the parallel fold lines.

The structure was found to be weaker along a/a'

Case 2 : Corrugations at an angle to the parallel fold lines.

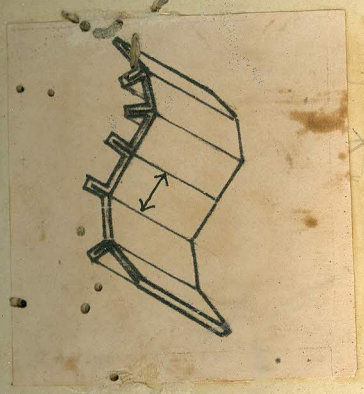
The structure was found to be weaker along b-b' and in

Case 3 : Corrugations along the parallel fold lines.

The structure was found to be weaker at c-c'. The most weakest structure amongst all the cases discussed above.

The resulting structure is strong when the ends are rigidly fixed.

4.2 Creasing and folding (rib structure)



This process results into a structure that gives following properties :

1. Ultimate structure is a rib structure which has got uni-directional strength. i.e. Stronger only along the direction of the ribs.
2. It is flexible across the direction of ribs and can give single curvature. See Fig. The resulting structure is strong enough only if the direction of corrugations are at right angle to fold lines but it is weak if the corrugations are running along the fold lines.

4.3 Cross creasing

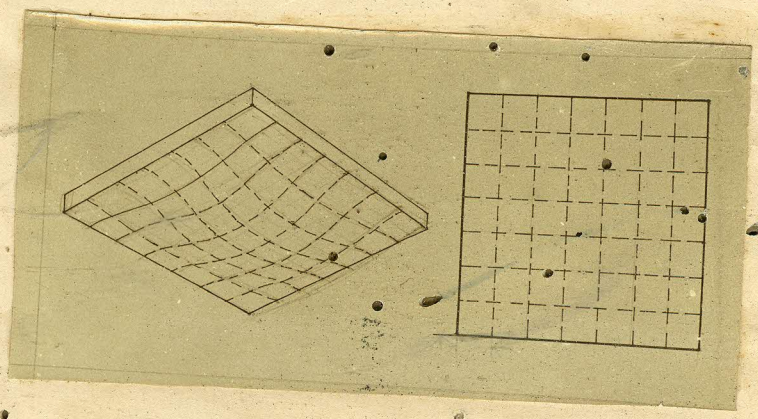
1. This process of cross creasing weakens the original strength and stiffness present in the material.

2. The plane become flexible as shown in the photographs.

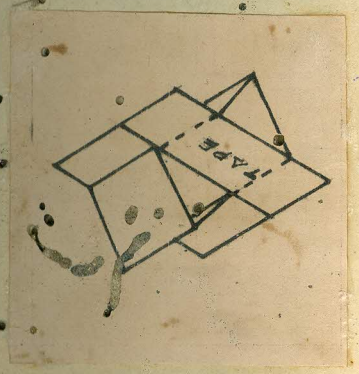
The extent of flexibility depends upon

1. Distance between the creasing lines
2. Pattern of creasing lines.

The resulting structure gives bi-directional concavity.



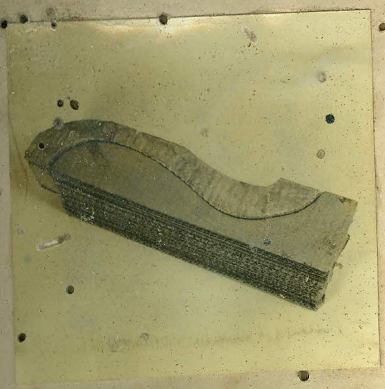
4.4 Slitting, creasing and folding



Corrugated board when slit , creased and folded in a way shown here give a particular configuration that shows wide potentials to develop it further. When it is taped as shown here gives good shock absorbing quality.

Due to its specific structure it also gives good interlocking possibilities which are discussed in chapters 5.1, 5.5.

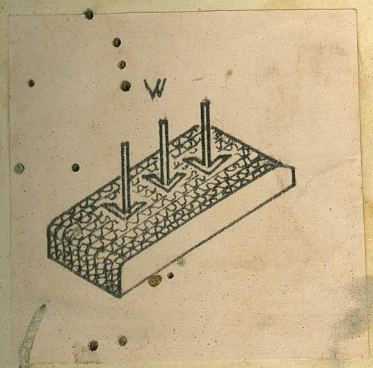
4.5 Laminating



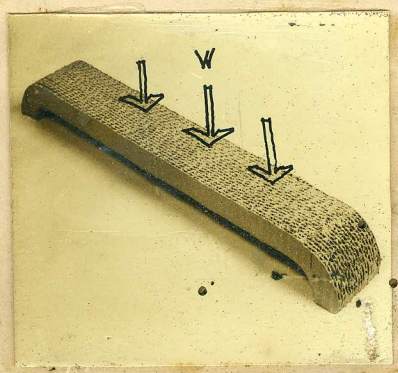
When corrugated boards are stuck on each other and cut across as shown here give following properties :

1. Resulting character of the material was found to be perforated.
2. It is possible to cut smooth curved surfaces as shown here.
3. Solid piece has got a good load bearing capacity if used under the situation shown in figure 3.
4. A sheet when used under the situation shown in figure 4. has less load bearing capacity and varies as per the thickness and the span.
5. Material has got more shock absorptivity when used under situation shown in fig. 5.

2.



3.



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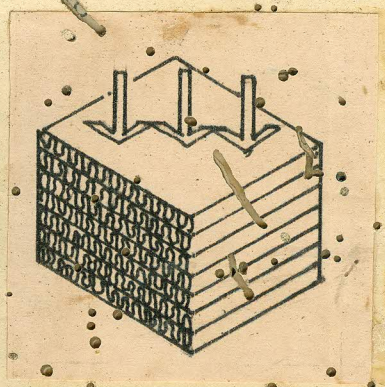
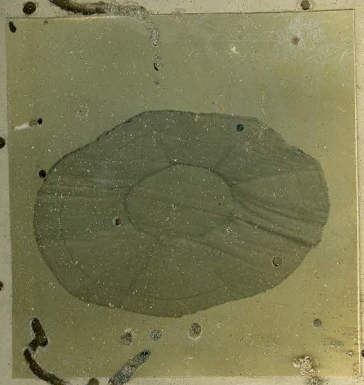


5.

4.6 Making the material wet, pressing and drying



Result of the process was as follows :

1. Corrugated board after pressing under wet conditions took the shape of the mould after drying.
2. It permanently retained the shape after drying.
3. The corrugations were damaged considerably.

Chapter 5 CONCEPT DEVELOPMENT AND POSSIBLE END USES

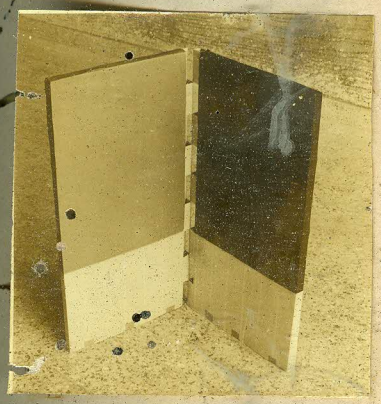
Preliminary explorations are further developed so that it will be used for the design of products in corrugated board. Suggested end uses are not the only uses but it is a proof to show that the concept works. Properties achieved through the way of using the material is discussed in the following chapters.

5.1 Rigid panels and interlocking

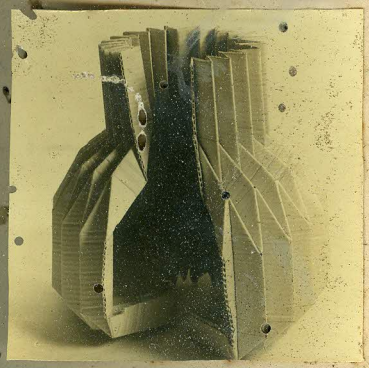
The folded plate structure due to its specific property as discussed in 4.1.2 can be used as an internal strengthening material.
The resulting sample product shown here is the combination of two different concepts 4.1.2 and 5.6.
The folded structure makes the panel rigid and the concept no.5.6 makes the interlocking system possible.

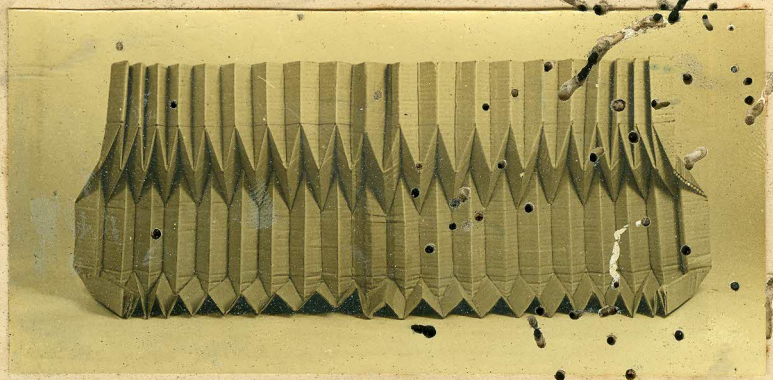
Possible end uses

. Exhibition panels, partitions, display platforms etc.
Short duration mobile exhibitions require display furniture which should be necessarily light weight and foldable to reduce the transport cost. The proposed design of a panel shown here is foldable and can be transported in flat sheet form.



DOUBLE FOLDED PLATE STRUCTURE FOR SPECIFIC SHAPES



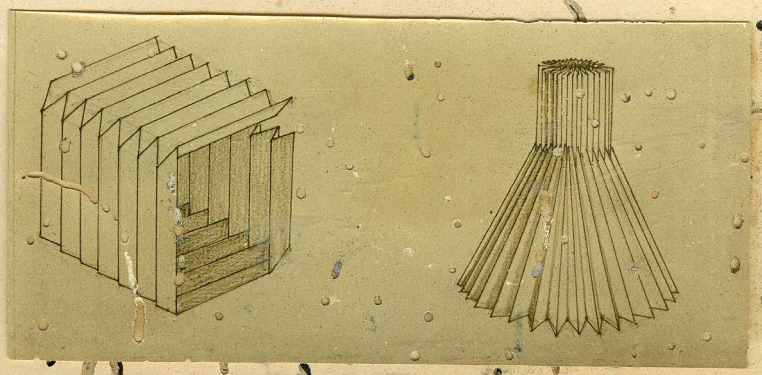


Development of the preliminary exploration 4.1.3 shows following properties.

1. Zigzag creasing and folding can give various 3-dimensional geometrical possibilities. 2. Due to its folded structure it is strong and impact resistant. 3. As it can take various geometrical shapes as shown here can act as a protective cover for the products 4. Effective protection through shock absorption is possible in minimum quantity of material.

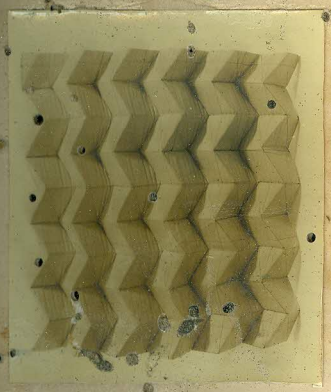
<u>Possible end uses</u>

Protective packaging for glassware such as laboratory equipments, ceramic products etc.



5.3 FLEXIBILITY IN PLANE -

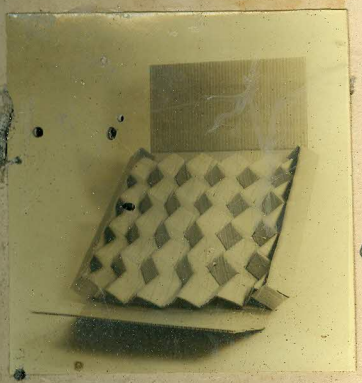
5.3.1 By zigzag creasing and folding



a.

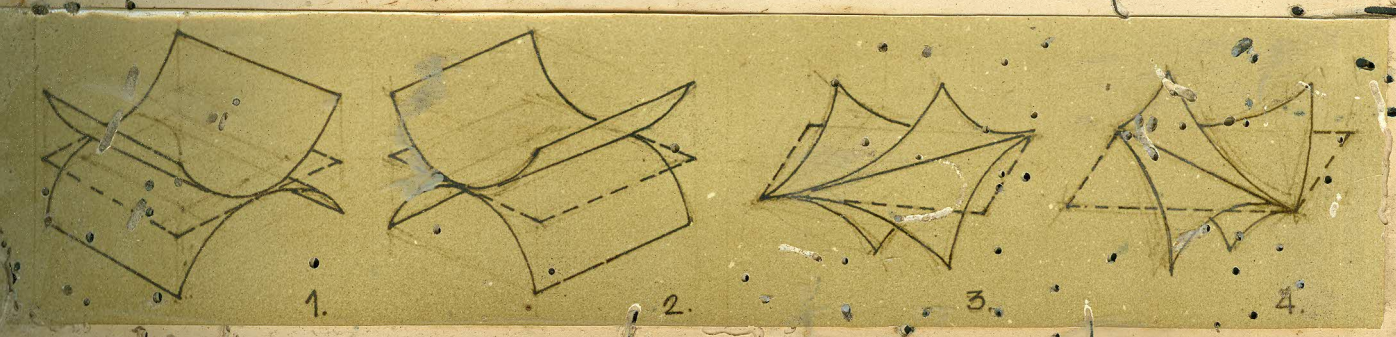
b.

Zigzag creasing and folding gives different structural configuration which shows still more different properties as described here.. 1. The structure shows flexibility in plane as shown in fig. d. 2. It is flexible enough to take a shape of a large sphere therefore can be used as a protective lining for double curvature products.. 3. Its particular structure has got impact resistance 4. It can act as an internal strengthening material if enclosed (C) 5. If stacked on each other . if forms uniform geometrical spaces inside (b) that will be useful for storing round or spherical fragile products. Product is securely held in position due to its cavaties..



c.

d.



5.3.2 Flexibility in plane by cross creasing

The specific property achieved by cross creasing described in 4.3 can best be used for containers as shown here. Such containers as shown here accommodate more material as it has got a tendancy to inflate to a certain extent due to the process of cross creasing.

5.4 Rigidity through rib structure

Rigidity through rib structure : Considering its flexibility in one direction and strength in another, if used in combination with a component supporting the ribs can form a strong structure which can take good amount of load. Single curvatures are possible due to flexibility in plane in one direction.

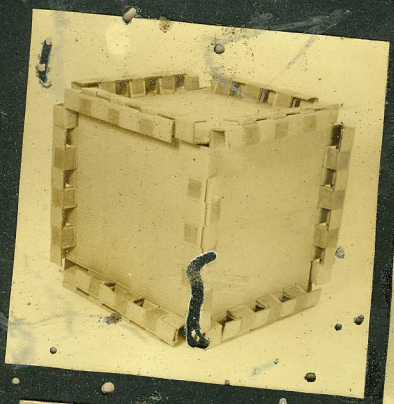
The chair developed on this concept can withstand 60 kg of load.

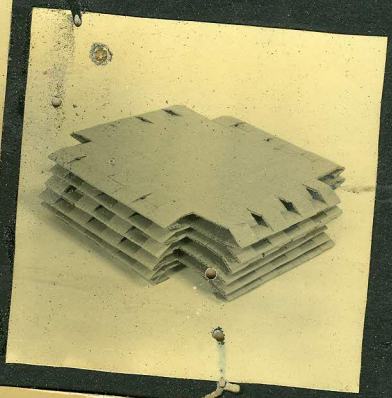
Possible uses

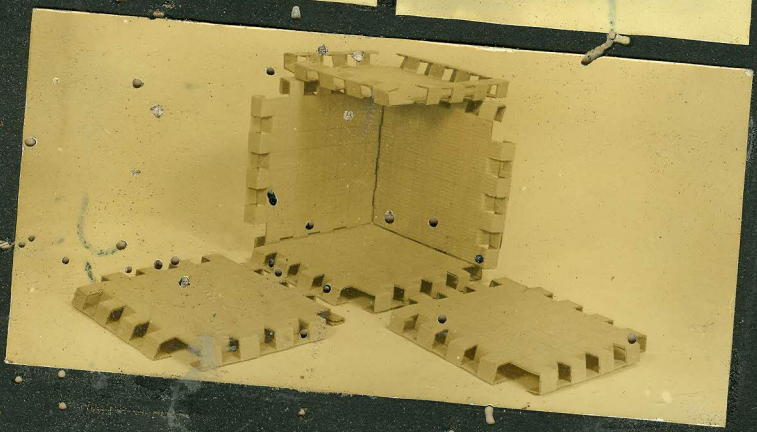
It can be used for chairs, tables for exhibitions and flat areas for display.

The chair is totally foldable with interlocking joints and can be carried in a flat sheet form.

120
450
800
350
500
30







5.5 Interlocking joints

By slitting, creasing and folding

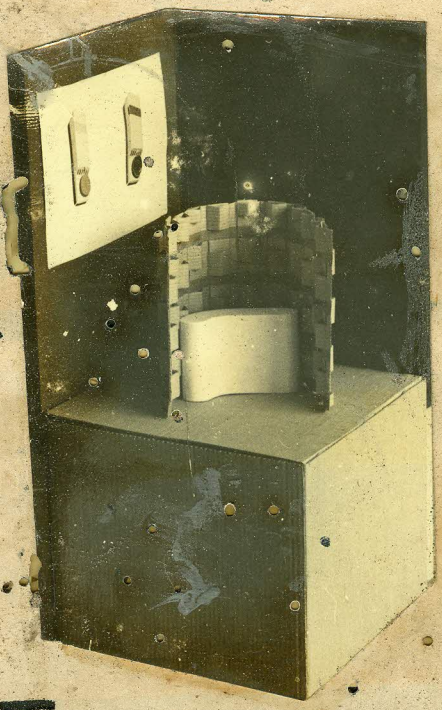
Based on this concept various joints are worked out by interlocking identical pieces and inserting a square pin. The joints can be released by removing the pins on clips.

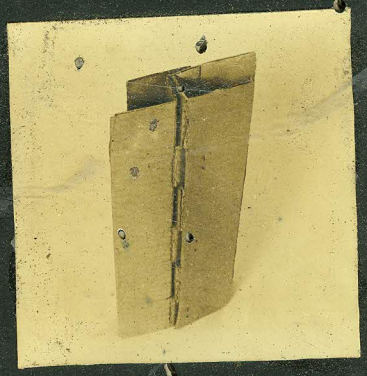
Types of joints possible

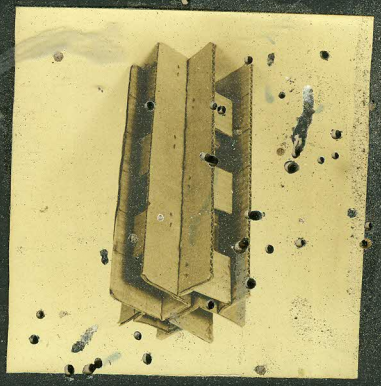
1. 'L' type 2. '+' type 3. straight type .

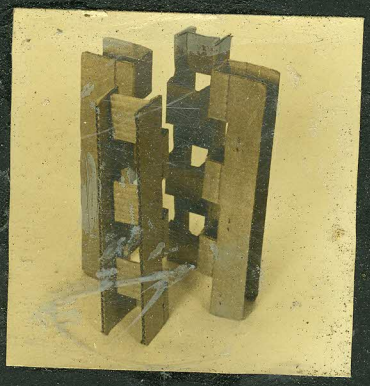
This concept can be used for exhibition panels which require foldability, light weight and interlocking possibility at different angles as the display needs demand. The exhibition panels shown here is the combination of two different concepts as explained before.

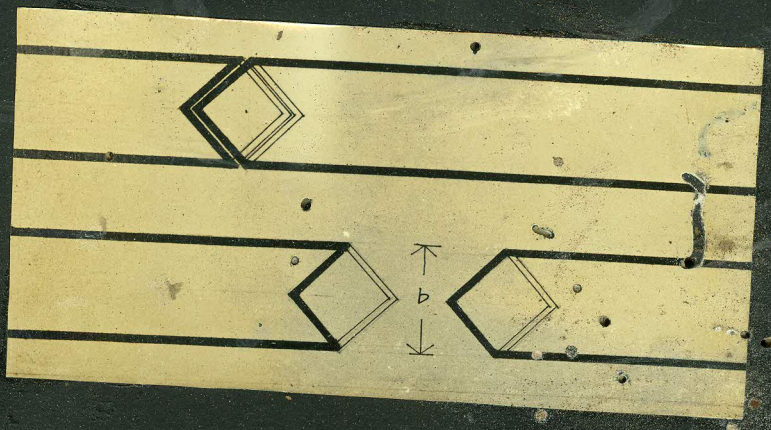
b = 250 a = 250 MM.

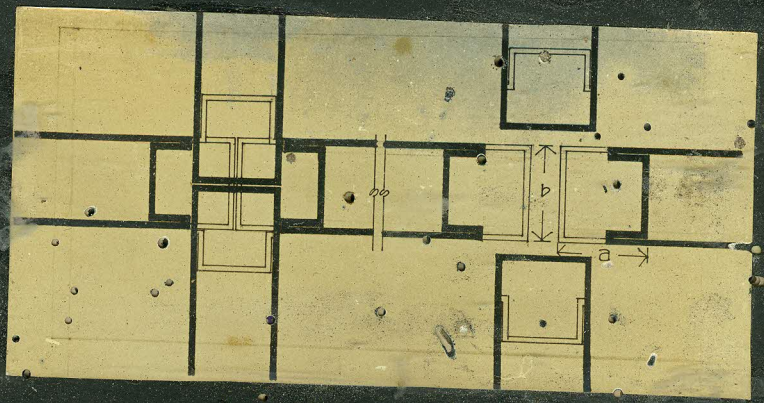









b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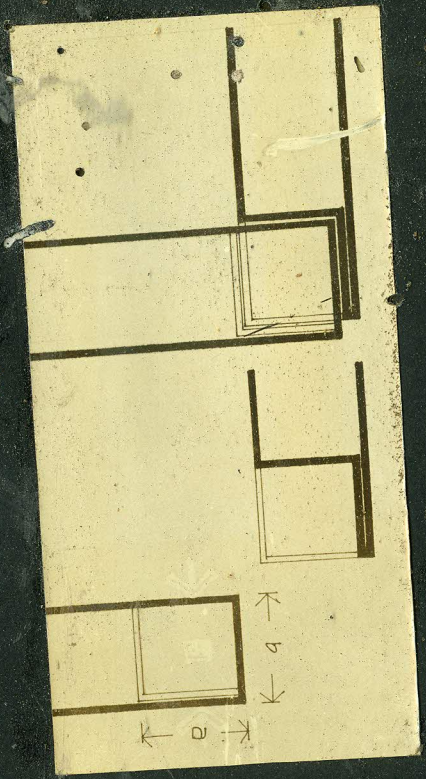
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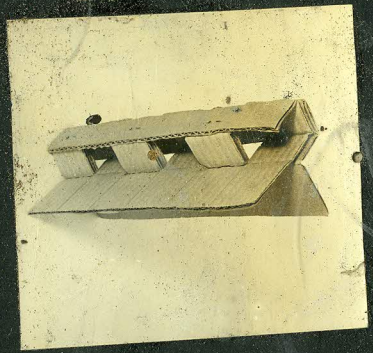
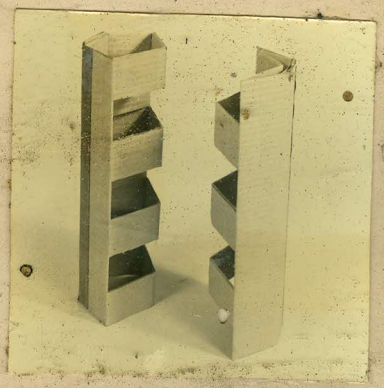
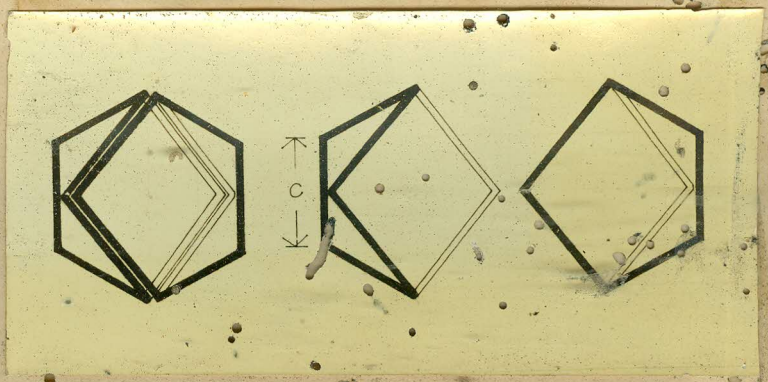


5.6 Shock absorptivity through structure

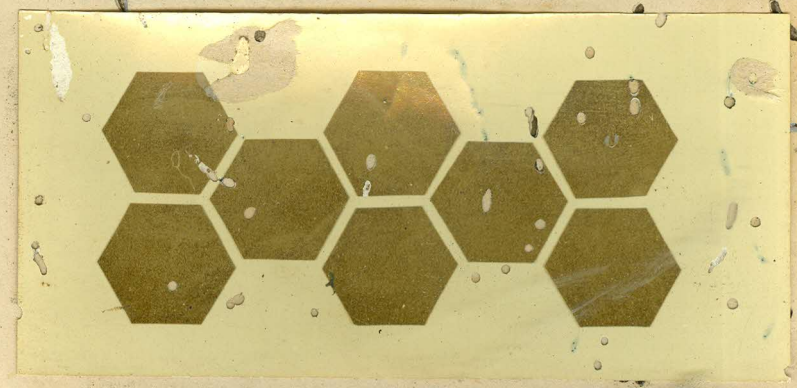
By slitting, creasing and folding

This property is an extension of 4.4 by developing a structure further. Resulting structure can be used as a protective package for fragile products such as thermas flasks, tube lights, laboratory equipments, ceramic products. This specific structure forms double casing around the product as shown here. No part of the surface of the product can come directly in contact with outer casing. Structure keeps uniform protective margin around the product.

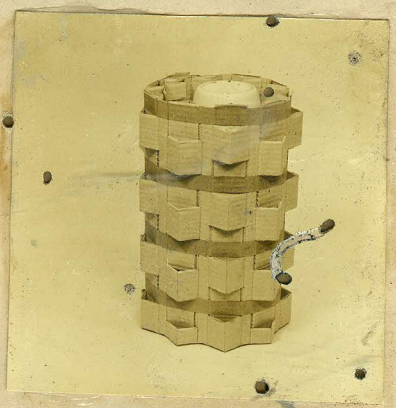




The hexagonal shape of this package shows good stackability which reduces the storing space.



The concept is further developed as shown here. The resulting product developed through this process of slitting, creasing, folding and taping gives structure that has got good shock absorption qualities.
This structure can be used as a protective lining for the product. The material can be rolled as shown in the photograph and hence can be used for protective lining for cylindrical products.
The tape used acts as a tie and the strips of corrugated board as spacers which control the internal dimensions of the diagonals.



Chapter 6. SUMMARY

Necessity of exploring the material was felt through its limited use and the limited ways of using the corrugated board at present. The aim of the exploration of the material was to widen the range of usability by building up new properties by using the material in different ways, and suggest more efficient solutions to the present ones. This will suggest a new and different direction of thinking which will help further exploration.

Basic data on corrugated board is based on available information since it was not possible to do experiments to generate such data. Short life being one of the salient characteristics of corrugated board the nature of the product made out of corrugated board will also have short life hence only such products which will be used for a short duration should be made out of corrugated board.

Initial approach to the problem was by listing out products which are used for short duration and studying whether they should be made out of corrugated board.

e.g. Products like prams, toys for children, tirdi (Bed for carrying a dead body), travelba

But this approach was no more followed as it failed to generate sufficient feed back on the properties of the material.
Later approach discussed in chapter.3 turned out to be more efficient than the previous one.
Chapter 4 convincingly proves that the ways of using the material gives different properties such as :

1. Flexibility in plane
2. Shock absorptivity
3. Rigidity
4. Interlocking possibility etc.

These properties when developed and used in isolation or in combination suggest different end uses and the end products in turn demand different properties to satisfy its function. The end products thus give a feed back and help further more exploration

All the products developed are foldable and can be transported in flat form (except 4.4 4.5), thus help saving the storage space and cost of transportation.
The products developed are at conceptual stage and further details about 1. flute characteristics, 2. physical strength required of liners and adhesives etc. will vary from product to product. The project

does not cover this area and only limited upto conceptual stage. The end uses suggested are not the only end uses but the properties developed can be used for any other similar situation.

ANNEXURE

Ultimate property of corrugated board depends upon :

1. Flute characteristics
2. Physical strength of the component like corrugating medium, liners and adhesives
3. Constructional qualities

Types of corrugated board available :

1. Single faced
2. Double faced
3. Double wall

Different sizes of corrugations are available.

Type	Flutes/ft.	Flute height
A flute	34 - 37	0.187"-0.189
B flute	50 - 52	0.097"-0.105
C flute	41 - 54	0.137"-0.145
E flute	90 - 96	0.85" -
Extra large	20	6 - 7 mm

Corrugated board with larger flute size has greater stacking strength and absorptivity (shock). A type : greater stacking strength, greater shock absorption. Generally used for glass ware. B type : stiffer, less shock absorption. At present the material is being used largely for packaging.

Advantages of corrugated board

1. Effective cushioning material

2. Light weight 3. Easy to manufacture

4. Easy for storing 5. Easy for disposal

6. Safe for human handling 7. Can be made water resistant 8. No self generating pests or fungus 9. Saves production space.

Water proofness
and
Weather proofness

can be achieved by plastic coating of PVC Polythene, Bituminised paper, coating with paraffin, Nitro cellulose, Ethylacetate, PVA, Saran resins (P.V.D.C.), Acrylics, Polystyrene and several other synthetic materials.

Manufacturing joints

Stitching : Wire stitching, stapling

Taping : HDPE reinforced box tapes
cloth tapes

Gluing

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