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STRENGTHENING OF THE TECHNOLOGICAL CAPABILITY
OF THE THAI PACKAGING CENTRE
DP/THA/87/019
THE KINGDOM OF THAILAND

Technical report: Development of packaging for distribution of fresh fruits and vegetables*

Prepared for the Government of Thailand
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of E. Pichler,
expert in transport packaging

Backstopping officer: J. Belo, Engineering Industries Branch

United Nations Industrial Development Organization
Vienna

* This document has not been edited.

V.92-51754

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ABSTRACT

In this project procedures were proposed for the experimental development and quality control of boxes for distribution of fruits, vegetables and fishery products in Thailand and neighboring region. The material selected for industrial production of these boxes in small scale factories is the rubberwood since it comes from reforested sources and has adequate properties. Bamboo was also studied with a conclusion that it is necessary its combination with other materials. Systems for treatment of wood and a brief cost analysis are suggested. The design of three boxes, in the proposed standard dimensions and with capacities of 100, 50 and 40 litres was developed with prototypes tested. The tests were intended also to verify the validity of the proposed procedure and to improve it. It is recommended that a national or regional technical standard be prepared based in the proposals, with the involvement of interested parties. It is recommended, in parallel, that field tests be carried out, also with participation and motivation of the interested parties. The proposed designs should be tested and compared with other alternatives. Bamboo baskets reinforced with wood or steel wires still have to be developed but a preliminary cost analysis discourage the use of bamboo.

I. INTRODUCTION

The work covered by this report, performed in December 1991/ January 1992, is a continuation of the work started in May 1990 by the consultant. This report is a continuation of the one presented in 5 June 1990, where the objectives of the project are defined according to a "job description", and where performance specifications of boxes for local and regional distribution of fresh fruits, vegetables and fishery products were proposed and four prototypes were designed.

This second part of the work involves a discussion of the performance specifications proposed, in the light of observations of tests performed with the prototypes, an advancement of alternative designs and a study of implementation of the project with proposition of initiatives.

The methodology of the work in this second part is based in a series of technical meetings with the laboratory team of TPC, the gathering of additional information in literature and visits, elaboration of new proposals and of conclusions and recommendations.

The technical meetings had also a complementary purpose of exchange of experience between packaging laboratories, on performance testing, since the consultant brings the experience of the Technological Research Institute of S.Paulo, Brazil.

The work was followed by photographs presented in the Annex.

II. REVIEW OF FIRST REPORT

A. Observations on the prototypes

The observation of the prototypes made according to the reccommentations of the first report and submitted to tests, as well as aditional experience of the consultant led to some adjustment in the proposed design of boxes.

The criterium of having a standard thickness and width of boards for each model of box, with the idea of introducing economies of scale in production and repair, resulted in very heavy and expensive boxes since the large thickness necessary in the parts which receive the nails was extended to all the structure. So the use of the "three way corner" also has to be reconsidered. The handling of the boxes by a two-wheel cart (Figure 1) is very important, requiring the design of a raised bottom for the introduction of the fork.

In relation with the width of boards attention must be given to the problem of large variations in the diameter of logs, with girths between 70 and 120 cm according to the Forest Industry Organization, Technical Division (Mr. Amnuay Kaewsingh). Variations in the width of boards of certain parts of the boxes must be allowed, with a minimum of 45 mm and providing that the gap between boards are kept with a maximum of 20 mm (30 mm in box B100, since it is destined to voluminous products). A certain amount of wane is also acceptable for some parts.

The dressing of the boards, with planning the two faces as recommended for sanitary reasons, led to boards of 10 mm instead of 15 mm as proposed for box C40, since the production of prototypes was based in traditional sawmill sizes. The thickness of 10 mm is not adequate for the boards to receive nails on the edge, or the nails have to be too small. It is recognized, however, that the use of traditional sawmill sizes is convenient to avoid resistance to innovation, making easier the introduction of the boxes into practice. The new designs should work, then, only with thicknesses of 10 and 22 mm, taken from undressed boards with the traditional 12 and 25 mm sizes.

In relation to the D30 bamboo baskets it was observed that the prototypes were made without a ventilated mesh. Since the baskets are so shallow ventilation by the top may be sufficient, with the advantage of a stronger basket.

B. Performance testing

Compression

- General procedure

The following test loads are recommended

Box	boxes in stack on truck	gross weight daN	Load daN
B 100	3	50	300
B 50	6	40	600
C 40	5	30	360
D 30	5	20	300

In spite of the capacity of some trucks allowing higher stack, reasons of stability of the stack limit the number of superimposed boxes. A safety factor of 3 was considered. The value of 4 proposed in the first report for reusable boxes was revised. It was realized that the number of trips would not alter substantially the resistance of the structure.

The duration of load of one hour was considered excessive since wood has no significant creep deformation at the low stresses applied. A duration of 15 minutes was suggested. Eventually 10 minutes may be used since it is important to reduce time when the sample is large. For other materials, however, it is recommended to keep the duration of one hour in the case of corrugated board, or to increase to 72 hours in the case of plastic boxes, or to reduce to one minute in the case of metalic containers.

- Discussion - This kind of static compression test does not show eventual problems of instability of the box, specially wooden crates, that may be a real problem in the transportation. Lateral oscilations of the truck, accelerations and the inclination of roads may impose shear loads in the structure of the box, with racking deformations. A new test method is proposed according to Figure 2, where the horizontal force is applied after the compression load.

- Observed procedure

A plate was prepared adequately, with a weight of 290 daN calculated. Since the travelling crane of the laboratory is used, making difficult to mark in the floor the position for the center of the box, a small hole was drilled in the center of the plate. The coincidence with the center of gravity was verified with a lead-line from the center of suspension. Through this small hole a vertical pointer, removable, can indicate the center of the box.

Instead of applying the load over a stack of two levels, the upper box was simulated by two boards. It is better, however, to keep the procedure formerly proposed.

A duration of load of 15 minutes was measured, with the loads indicated in the table on page 5.

- Results. The wooden boxes had no significant deformation but the bamboo baskets, arranged according to the figure in Anex II, 1.2 of the first report, were not able to withstand the 290 daN of the plate, collapsing simutaneously with the application of the load.

A dynamometric compression evaluation of the bamboo baskets gave the results presented in Figure 3.

<u>Lifting</u>

The simulation of handling according to the proposed procedure (Annex II, 2 of first report) showed good performance of all the prototypes.

The handling with a two wheel cart inserted under a stack of boxes was simulated during the compression tests with the larger prototypes, with the load applied to boards under the compressed box. Deformation of the bottom was appreciable but there was no rupture.

It is important, in the standardized procedure, to reproduce this kind of test.

Stability

The evaluation of stability of stacking was carried out as proposed, with a wooden base being raised at one extremity by a manual hoist. It was verified that the bottom box had to be fixed to the base plate not only against sliding but also against turning, specially in the case of higher boxes.

There was no problem of stability in the direction in which the upper box is restrained by the protruding edges of bottom one. In the other direction it was not possible to reach the proposed 45° angle since the stability was only provided by friction. The friction coefficient between wood and wood is around 0.8, with a slide angle around 40° . So the previous proposal of 45° is reconsidered with a recommendation of a maximum angle of 40° between the base plate and the horizontal.

This test is proposed only for the approval of a design but not for control of quality in industrial production.

Puncture

- General procedure

The proposed procedure (Annex II, 6 of first Report) was followed, with investigative impacts of 5, 10 and 15 J.

With 10 J a board damaged by insects was broken and sound boards resisted the impact, what shows a good sensibility of the test with that intensity.

The equipment made according to the draft presents some problems. The lines of the pendulum are too short. They have to receive a large inclination for a certain amount of energy (15 J, for instance) resulting in a large horizontal force. It is difficult to adjust the release position.

It would be better to fix the pulleys of the pendulum to the fixed beam of the travelling crane, for instance. Another advantage would be that the pendulum would not use space of the laboratory when not in use, if raised to roof level. A magnetic release device could be used (Figure 4).

- Discussion - The use of this kind of conic point in the pendulum, in the laboratory of the consultant, proved to be too severe for corrugated board boxes. The pyramidal point of AFNOR gives a less severe puncture, more compatible with the reality, but introducing the influence of direction of the edges in relation to the flutes of corrugated board. A spheric point with 50 mm of diameter is a new proposal, inspired by the ASTM D 2394. In the Brazilian draft standard of boxes for wholesale distribution of fruits and vegetables this spheric impact surface is applied with an energy of 5 J, too low in the opinion of the consultant. The conic point of the pendulum is still recommended for fiber drums.

Vibration

The proposed procedure was followed but with a variation rate of 0.5 octave per minute, according to ASTM D 999. The test was discontinued since it was observed that no damage at all would occur with the weakest of the wooden boxes. This test is actually valid only to evaluate damages to the product, not to the package. The resistance of boxes to dynamic compression was already verified in the static compression test with a safety factor involving the dynamic factor. So, it is proposed that this test be disconsidered in the standard procedure, being applied only for special studies, like on the fatigue of the bottom of boxes with a certain structure (wirebound boxes may present problem) for instance.

The suggestion that bags with sand and sawdust may be used as a dummy load in vibration and repetitive shock test must be revised. Any leakage of sand may seriously damage the vibration equipment. Besides this, the sand with sawdust has low flow, so there is little pressure exerted on the walls of the package under test. Bags with plastic pellets are now recommended.

Repetitive shock

Was performed only with the weakest of the wooden box prototypes (C 40), with a stack of five on the vibration table. The proposed procedure was followed.

This test is more severe than vibration and, if performed, it is another reason to disregard the vibration test. It is, nevertheless, open to discussion the validity of this test since repetitive shock takes place only when the boxes are not adequately lashed to the truck.

No damage was observed in the tested prototypes.

It is suggested that this test be maintained in the standardized procedure for the approval of new box designs and materials, but it is recognized that further research is necessary in order to find a correlation between test duration and distance of transportation (and number of trips in the case of returnable boxes).

This test should be disconsidered in the control of quality in industrial production of boxes with design already approved.

Drop tests

The proposed procedure was followed but the drop height was calculated from the given formula rounding to the nearest higher multiple of 10 cm .

Box	Gross mass	h (cm)	E (J)
B 100	50 kg	20	100
B 50	40 kg	30	120
C 40	30 kg	40	120

It was realized that the formula given by the Recommendation on the Standardization of Packaging for the International Transport of Fruits and Vegetables, of the Inland Transport Committee of the Economic Comission for Europe (in Ref. 01), in which

$$h\ (cm) = 70 - \text{Gross mass}\ (kg),$$

gives very low values of energy of impact for the very heavy boxes (60 kg: 60 J, for instance), so it may be considered valid only for boxes with gross mass lower than 45 kg (110 J).

A lower limit is also necessary since very light boxes would also have low impact energy. A minimum gross mass of 20 kg (100 J) is a reasonable value for the application of this formula.

A drop test of empty boxes was introduced, since they are returnable. A free fall of 1 m, with impact in a bottom corner in a vertical diagonal was applied. A C 40 prototype specimen was damaged in this test.

- Criteria for Approval

Procedures for sampling, inspection and classification of defects are necessary.

Class A (critical) defects are (e.g.):

- dimensions out of tolerance;
- breakage of a critical part in any of the tests;

Critical parts are those impossible to be replaced, like parts 1, 2 and 5 in the proposed designs of boxes B 100 and B 50 (Fingures 5 and 6).

Class B (major) defects are (e.g.):

- breakage of parts that can be replaced (sides and bottom boards) if they are not more than one in a box, in any of the tests;
- nails with a protruding point that can hurt persons or the produce;

Class C (minor) defects are (e.g.):

- loosening of nails, in any of the tests, that can be rehammered.

The AQL values may be 2.5% for class A defects, 6.5% for class B and 15% for class C (Ref. 02).

The sampling for approval of a design may have the boxes numbered:

model	repetitive shock	other tests*
B 100	boxes 1, 2, 3 in a stack	1, 2, 3
B 50	boxes 1 to 6	1, 3, 5
C 40	boxes 1 to 5	1, 3, 4

* Stability test in only one of the boxes.

In this case, only one minor defect is acceptable, in all the tests.

In the case of quality control of a lot it is reasonable to work with the special inspection level S 3 of the Military Standard, using normal simple sampling.

For a lot size between 1201 and 3200 boxes, for example, a sample of 13 boxes in necessary. Repetitive shock and stablity tests are not performed. In the case of model B 50, for instance, 12 boxes would be tested in compression, in pairs of superimposed specimens, the 13 boxes in drop test (four drops per box, one drop per empty box), lifting (inclusive lifting of stack by cart) and puncture (one impact per box, in different positions).

In this case only one class A defect is acceptable, two class B and 5 class C, for the approval of the lot.

C. New designs

Wooden boxes

The new proposed designs of the wooden boxes are presented in Figures 5, 6 and 7.

Bamboo baskets

The low resistence of the baskets in compression lead to two alternatives: the development of a system of physical distribution without stacking, or the design of a structure where the bamboo is reinforced, eventually with other materials.

The reinforcement of the already prepared prototypes with corner uprights made of 100 x 10 mm boards stapled to the open mesh structure of bamboo was tested, with negative results. The reinforced baskets suffered racking deformation simultaneously to the application of the 290 daN plate. This result led to the abandonment of this line of design of bamboo baskets and the search for other alternatives.

Another alternative of bamboo boxes involves the use of a bamboo mat bonded with phenolic resin. A design is presented in Figure 8. Here the dimensions do not follow de original criteria: the best use of bamboo mat in standard 1200 x 2400 mm size and a smaller volume (14 litres, since the structure will be not so strong) are the new criteria for this particular tentative. The minimum area of mat for given volume is obtained with the ratios L = W = 4H. In order to have the interlock of empty baskets these ratios were slightly altered.

Another possibility to be experimented is just the reinforcement of the bottom of the large traditional baskets with a wooden base that would give higher resistence to friction against the soil. This would increase the life of the basket and make easier the handling with the two wheel cart. Figure 9 gives an idea of this possibility.

The investigation of properties of bamboo in bent pieces or mats, and of technical procedures to bend it with a minimum loss of strength, is a proposed research.

The use of steel wires intertwined with the bamboo structure is also a possibility to be studied. The combination of tradition with new materials, however, more than a technical difficulty, may be a cultural problem. Only the experience and demonstration of practical results may give rise to new traditions.

III. WOOD TREATMENT

Rubberwood is very susceptible to attacks by fungus and insects. Most of the prototypes used for testing and observation were infested and damaged by xylophagous insects.

The problem of treatment with toxic products is the compatibility with the use of box for food. Safe products like "Copper 8" (copper 8 quinolinolate) are quite expensive and not available in Thailand, according to contacts with possible suppliers.

A light treatment is envisaged at the sawmill with the toxic agent diluted in the kerosene used, according to Ref. 03, as a lubricant of the saw against clogging of the teeth by latex. Insecticide agents like gamma benzene hexachloride, together with captafol fungicide are possible agents to be studied. After drying, planning and cross cutting, the parts of the boxes may receive an anti-fungus treatment similar to the used in phytosanitary protection of fruits.

An experimental study is nevertheless necessary, with the participation of other areas of the Thailand Institute of Scientific and Technological Research (TISTR), the Forest Industry Organization and the Faculty of Forestry. The TISTR has capabilities in biotechnology, agrotechnology and pharmaceuticals that could co-operate in the development of safe wood preservation systems for the proposed boxes.

IV. COST ANALYSIS

The cost of a traditional 100 liters bamboo basket is between 50 and 75 Baht.

The cost of a wooden box with the new proposed design is estimated in the same range.

This estimate is based in a cost of rubberwood of 33 Baht/dm^3 , a cost of labor of 15 Baht/box and 5 Baht/box of investment amortization.

The cost of 3 Baht/dm^3 of wood involves a certain treatment, according to Chapter III. It is very subject to variations in the economies of scale, transportation and systems of production and treatment.

The cost of labor was based in an operation with 10 workers with an average daily cost of 300 Baht each, producing 200 boxes/day.

These estimates, of course, are very dependent also on conjunctural or historical conditions, or trends. According to Dr. Songkram Thammincha of Kasetsart University, Faculty of Forestry, there is no management of the bamboo forests and no reforestation, so the availability of bamboo will be soon limited for more expensive applications, like in domestic decoration.

In terms of cost of the package, presently, there will be not a substantial advantage in the use of boxes instead of baskets. The advantages are in the logistics and in reduction of damage to the produce. A better use of the truck and handling facilities are envisaged.

The total capacity of the truck may be exploited even with the baskets if they are placed in removable shelves fixed to a structure in the cargo bed, so that no compression load is applied. This practice is occasionally observed. The difficulties of handling, however, are considerable.

The cost of transportation per box is dependent on the number of boxes a truck can carry per trip and the number of trips in a certain period of time. The number of boxes per truck analysed in the first report must be reconsidered in function of the new proposed stacking heights. The adaptation of trucks to an operation of maximum efficiency, specially in the ratio size of the bed/ cargo capacity in weigth, given the limitations in stacking height, is something that may develop along time.

The efficiency in the operation of the truck, specially in short round trips as between a distribution center and points of sale, is dependent on the time necessary for loading/ unloading.

With bamboo baskets manually handled, stowed in shelves in the truck, the movement of 100 kg/minute is estimated, with four men. With boxes, using the procedure suggested in Figure 1, a flow around 300 kg/minute is estimated, with three men and two carts. If the truck is operating in a dock of a supermarket, for instance, without vertical movement, a flow of 500 kg/minute may be envisaged with two persons and two cards.

It is very difficult to transform these estimates in cost estimates, since they are not precise enough. A real times and methods survey would be necessary, of experimental shipments.

In terms of reduction of damage to the produce with the boxes replacing the baskets, it is also to difficult to estimate the costs. The damage caused by deep baskets is identified as a serious problem in the Background Information to this project, as well as in Refs. 04 and 05. Again, only field tests may show the economic advantages of boxes in the protection to fruits and vegetables.

In the case of boxes for fishery products, being indicated in the first report a box size B 50 with a polyethylene liner, tests are also necessary, besides the economic study, to verify the technical feasibility. It is feared that corrosion of the nails would reduce drastically the life of the box.

V. RECOMMENDATIONS

The development of a package or of a packaging and distribution system is necessarily an experimental process. This process requires laboratory and field tests. Laboratory tests demand good technical standards, both for performance testing methods and for performance specifications. Field tests also require certain procedures and are generally associated with cost analysis, which involves an analysis of times and methods and other evaluations of efficiency.

In the development of boxes for national and regional distribution of fruits, vegetables and fishery products the first thing to be prepared is a national (or regional) standard. In this project procedures and intensities of tests were discussed and developed. The use of the proposed performance specifications in the elaboration and edition of a Thai Technical Standard (or Regional in the area of ASEAN) is the first recommendation. In order to have a standard with a high degree of respect it is important to have the involvement of future users in its preparation. To bring about this involvement a Seminar on the subject is recommended with participation of governmental authorities related to the social and physical distribution of fresh produce and fishery products, as well as representatives of producer and distributer organizations, cooperatives and private business. Authorities in the area of forest resources and wood technology should also be invited. A Seminar like that would create an impact and interest in an intensive work on the subject. Besides the work of standardization and complementary to it a field test is recommended. The field test may be based in the proposed design of boxes but other alternatives should be considered for comparison. A comparison of results in field and laboratory tests is a good way to improve the quality and the reliability of the performance standard. The field tests are also psychologically important in the participation and motivation of future users of the new packaging system.

Some minor recommendations were discussed in the technical meetings, related for instance to the puncture test, the dummy load of packages in drop test, vibration and repetitive shock, the importance of a programable horizontal shock tester and other aspects not necessarily related to this project. Some suggestions of research were given, even in terms of co-operation with the laboratory of the consultant, in the Technological Research Institute of S.Paulo State, Brazil. A technical visit of three or four weeks to this Packaging Laboratory and associated material technologies laboratories (wood, for instance, in relation to this project) is suggested and offered by the consultant for one or two researchers of TPC.

FIGURES

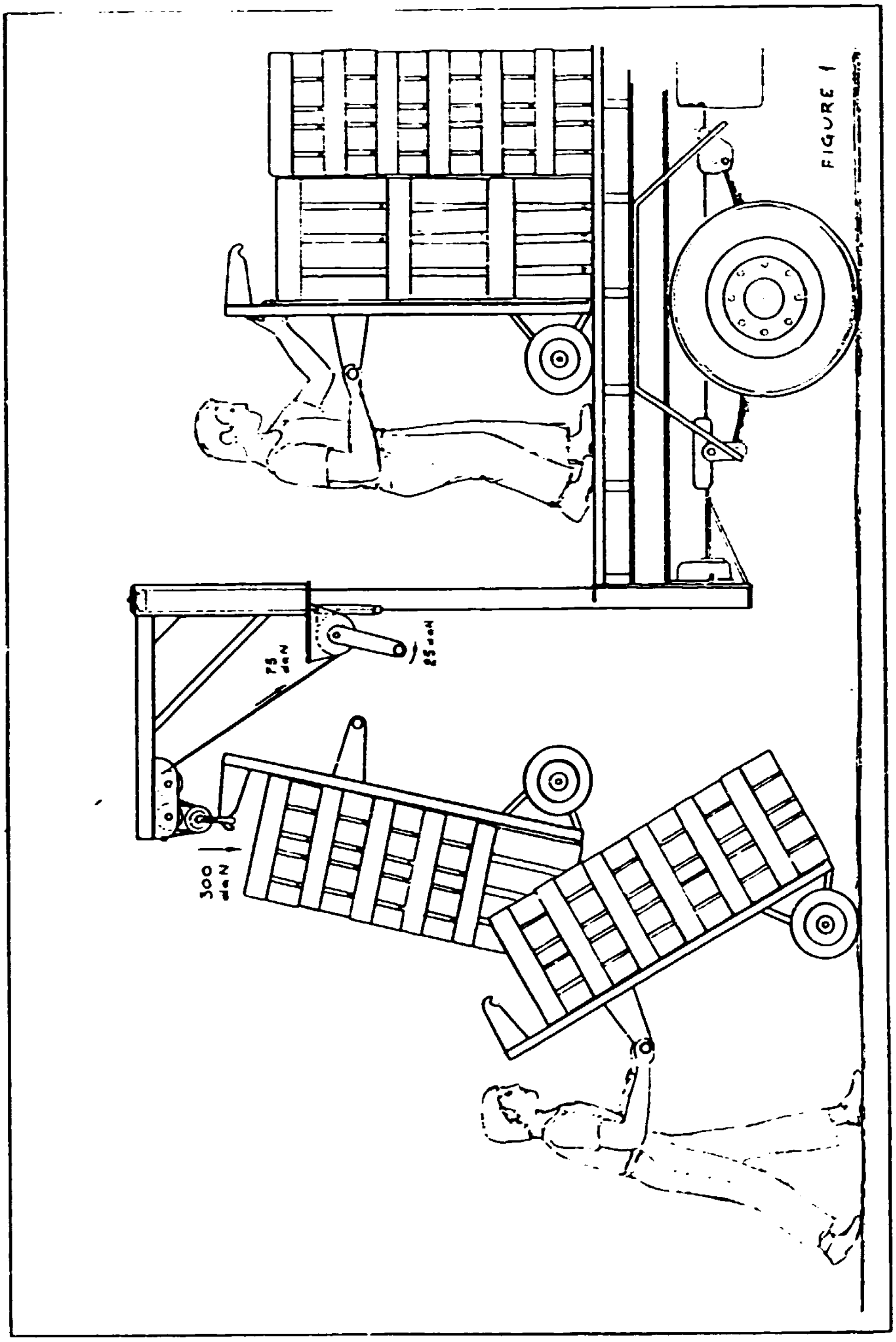


FIGURE 1

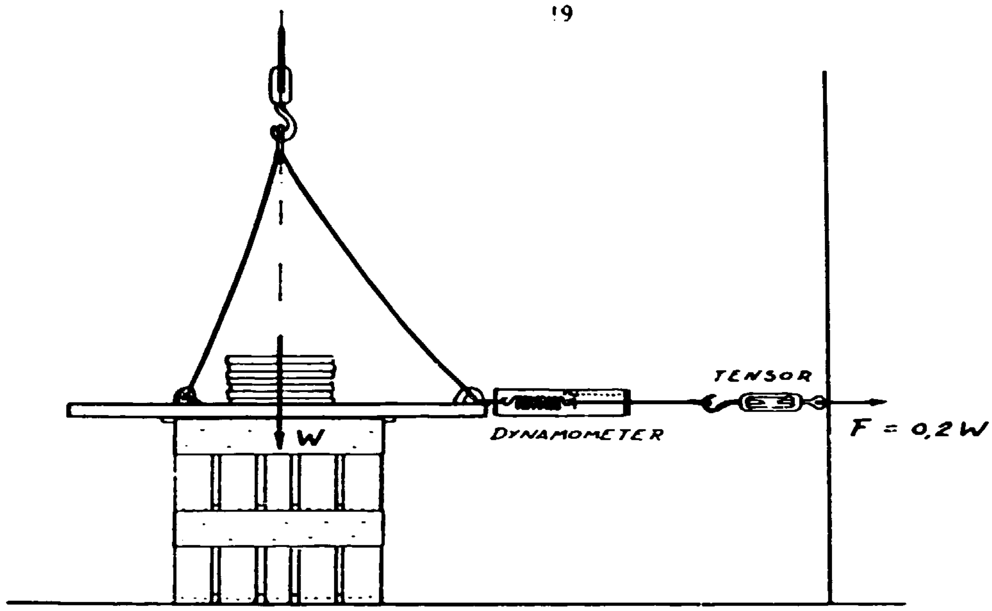


FIGURE 2

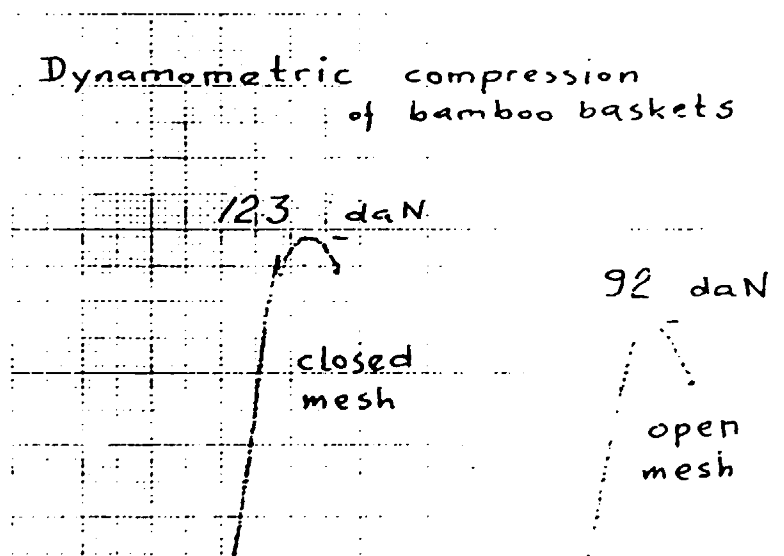


FIGURE 3

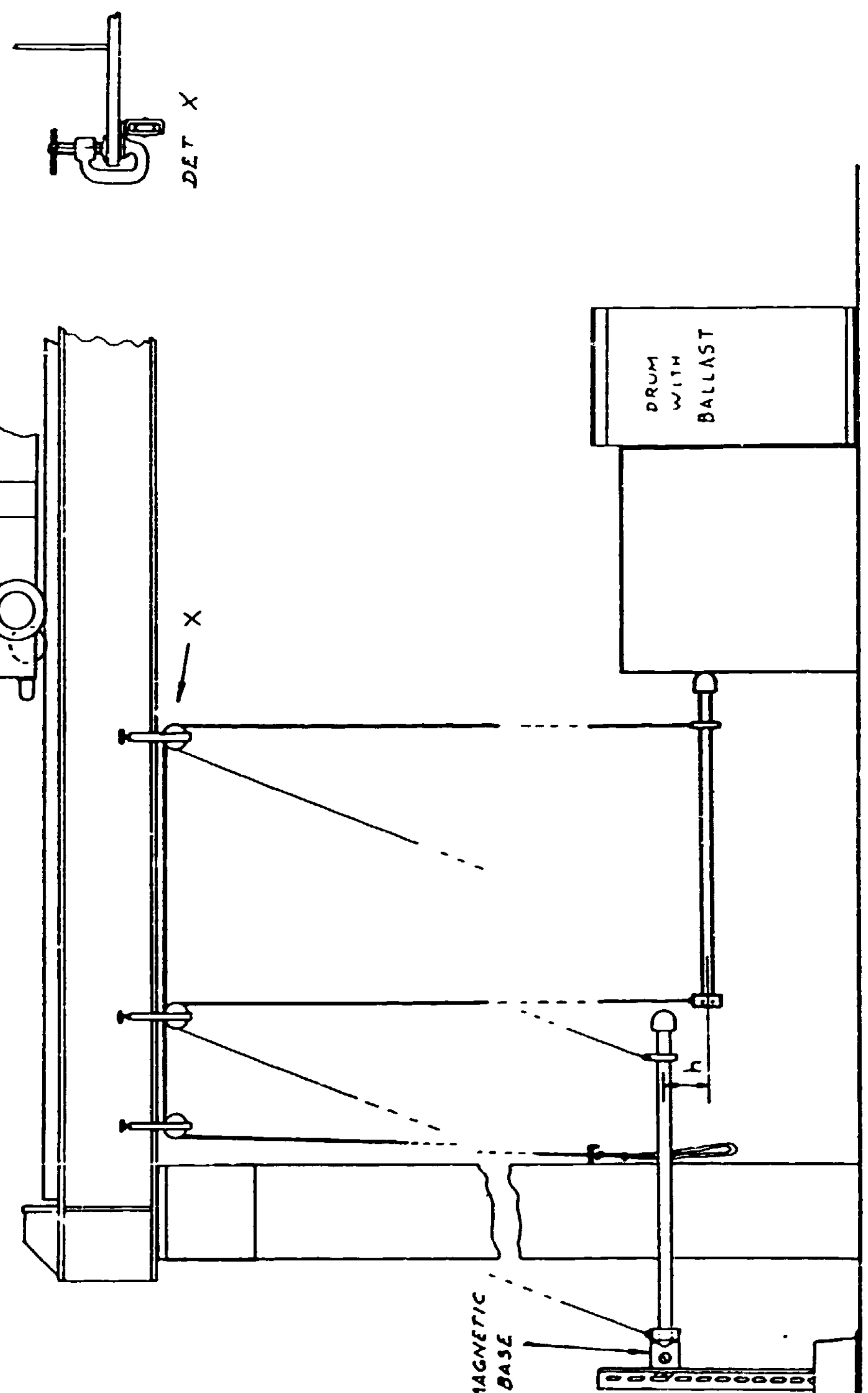
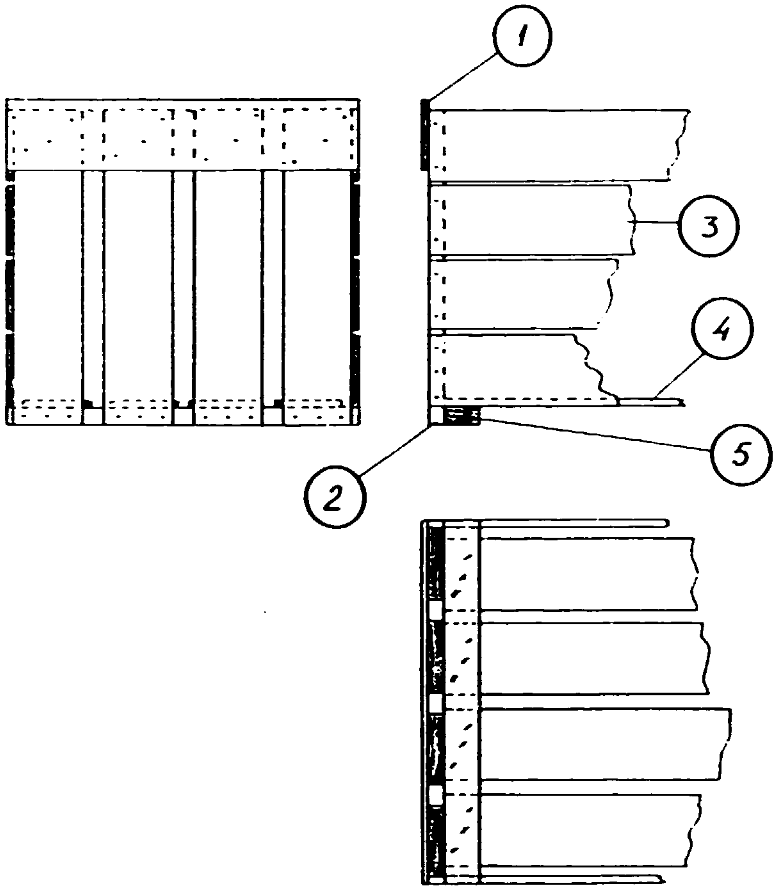


FIGURE 4

B 100



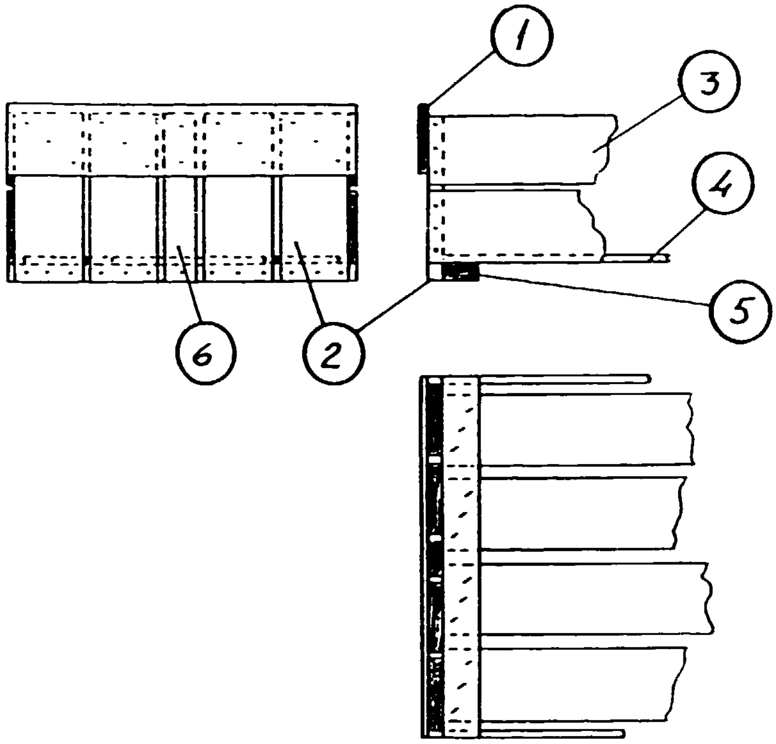
ITEM	DIMENSIONS (mm)	QTY.
1	100 x 10 x 510	2
2	100 x 22 x 442	8
3	100 x 10 x 580	8
4	100 x 10 x 536	4
5	48 x 22 x 510	2

108 nails ⌀3 x 50

EXTERNAL : 600 x 510 x 455
INTERNAL : 536 x 490 x 410
CAPACITY : 100 Litres
WOOD : 17120 cm^3
TARE 12 kg
GROSS WEIGHT 42 daN
with apparent density of product 0,3 $\frac{daN}{dm^3}$

FIGURE 5

B 50



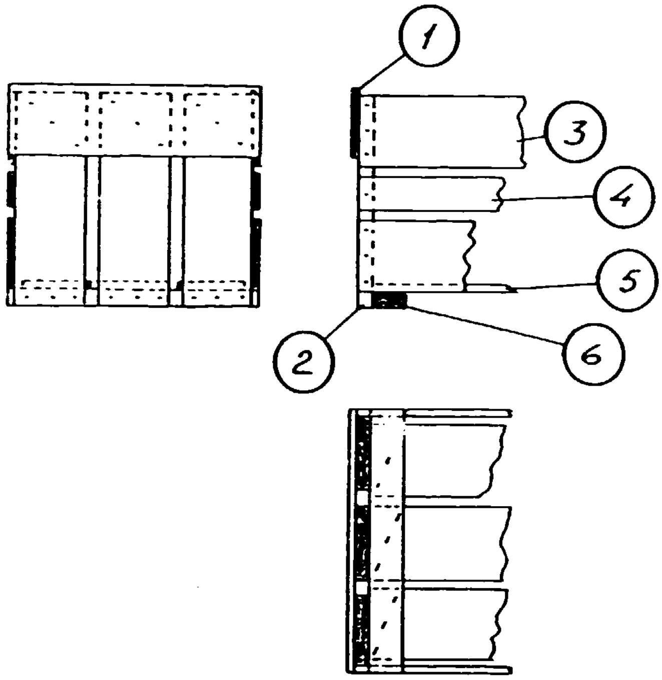
ITEM	DIMENSIONS (mm)	QTY.
1	100 × 10 × 510	2
2	100 × 22 × 230	8
3	100 × 10 × 580	4
4	100 × 10 × 535	4
5	48 × 22 × 510	2
6	48 × 10 × 230	2

102 nails $\phi 3 \times 50$

EXTERNAL : 600 × 510 × 240
INTERNAL : 535 × 490 × 198
CAPACITY : 50 Litres
WOOD : 11090 cm^3
TARE : 9 kg
GROSS WEIGHT : 35 daN
with apparent density of product : 0,5 $\frac{daN}{dm^3}$

FIGURE 6

C 40

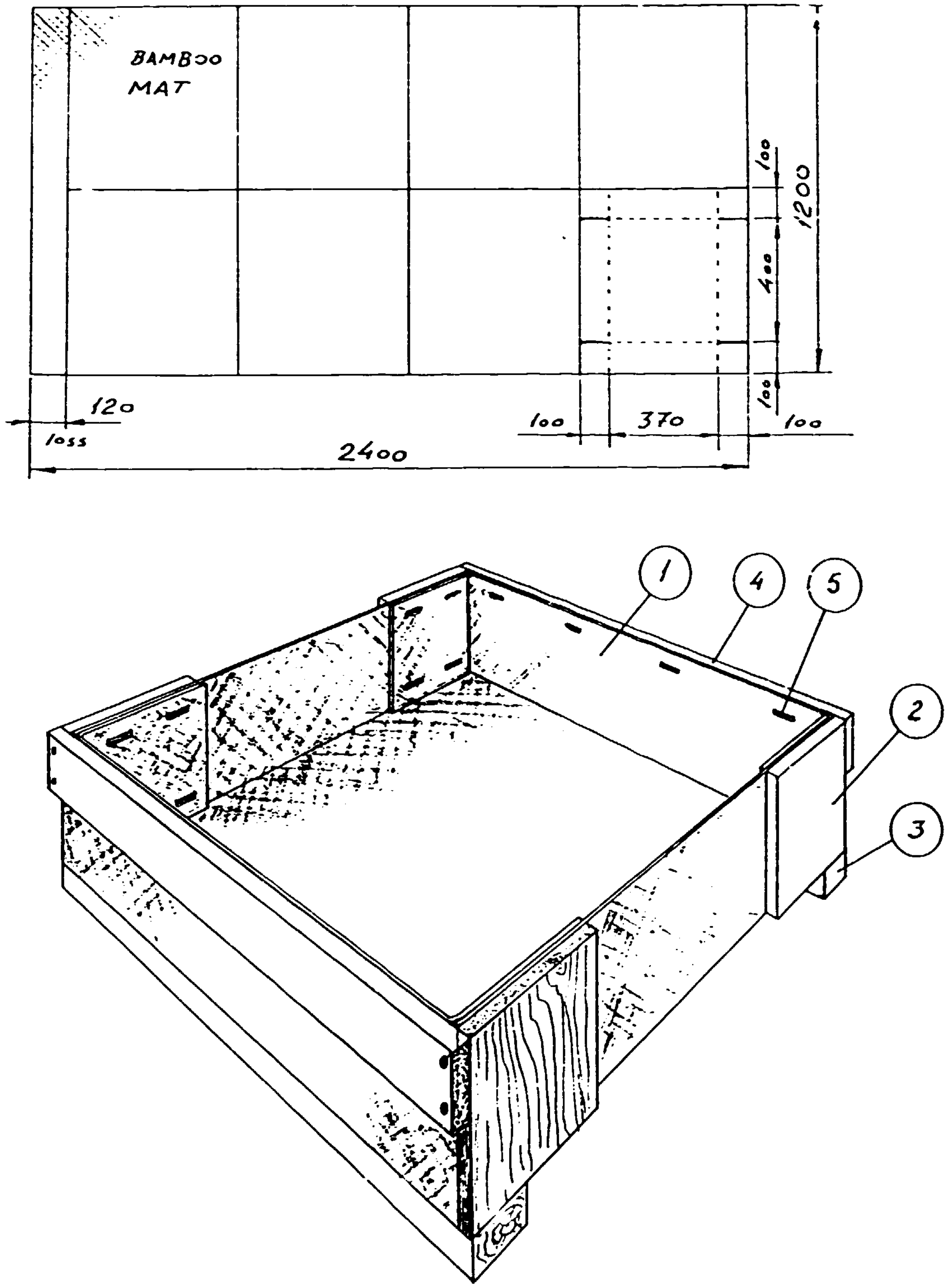


ITEM	DIMENSIONS (mm)	QTY.
1	100 × 10 × 370	2
2	100 × 22 × 300	6
3	100 × 10 × 480	4
4	48 × 10 × 480	2
5	100 × 10 × 436	3
6	48 × 22 × 370	2

82 nails ⌀3 × 50

EXTERNAL : 500 × 370 × 310
INTERNAL : 435 × 350 × 268
CAPACITY : 40 Litres
WOOD : 9170 cm^3
TARE : 6.5 kg
GROSS WEIGHT : 27 daN
with apparent density of product : 0,5 $\frac{daN}{dm^3}$

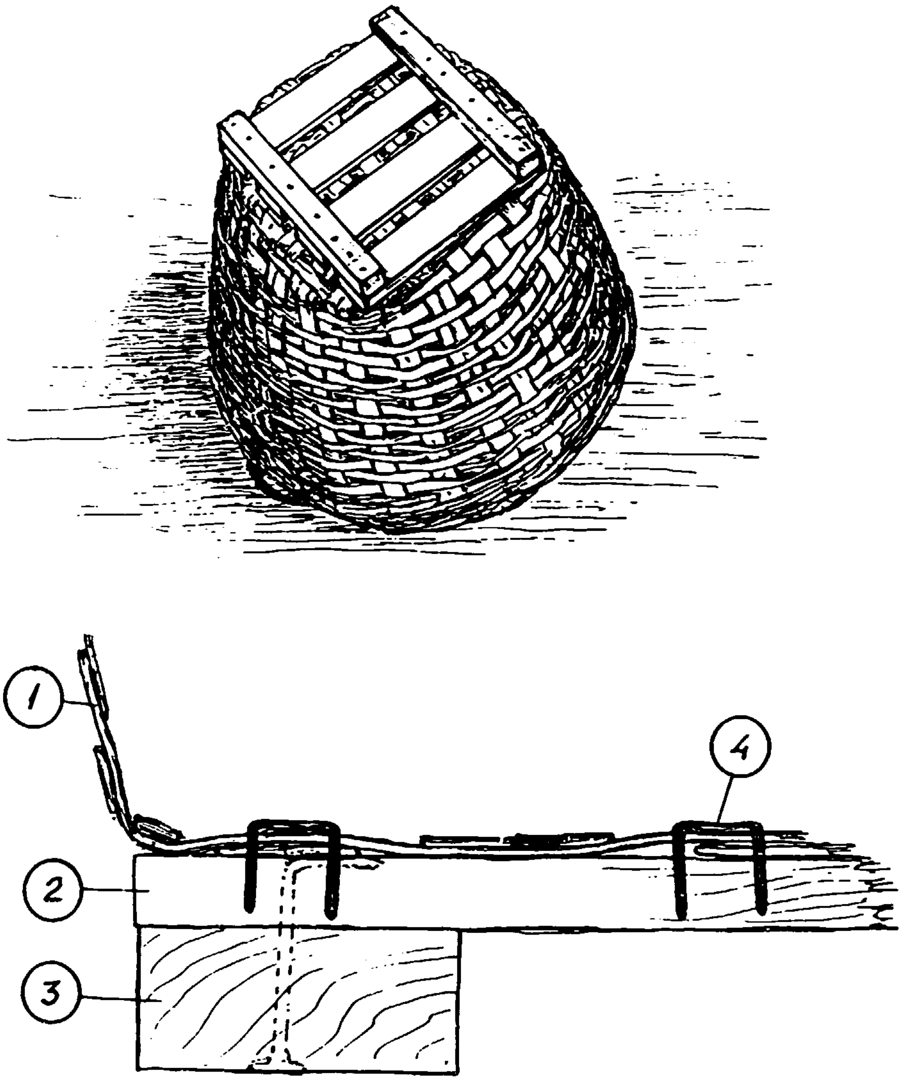
FIGURE 7



ITEM	DIMENSIONS (mm)	QTY.
1	BAMBOO MAT	1
2	100 × 10 × 100	4
3	45 × 22 × 370	2
4	45 × 10 × 370	2
5	stapla 15 × 10	24

CAPACITY 14 Litres

FIGURE 8



ITEM	DIMENSIONS (mm)
1	BAMBOO BASKET 100 litres
2	~ 50 × 10 × ~ 300
3	~ 50 × 20 × ~ 300
4	STAPLE 15 × 15

FIGURE 9

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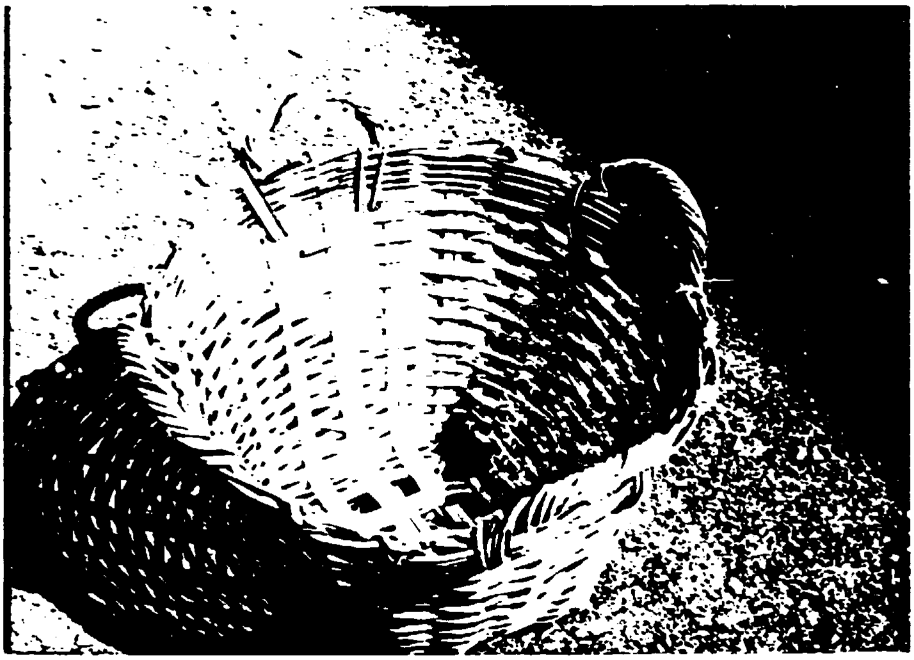
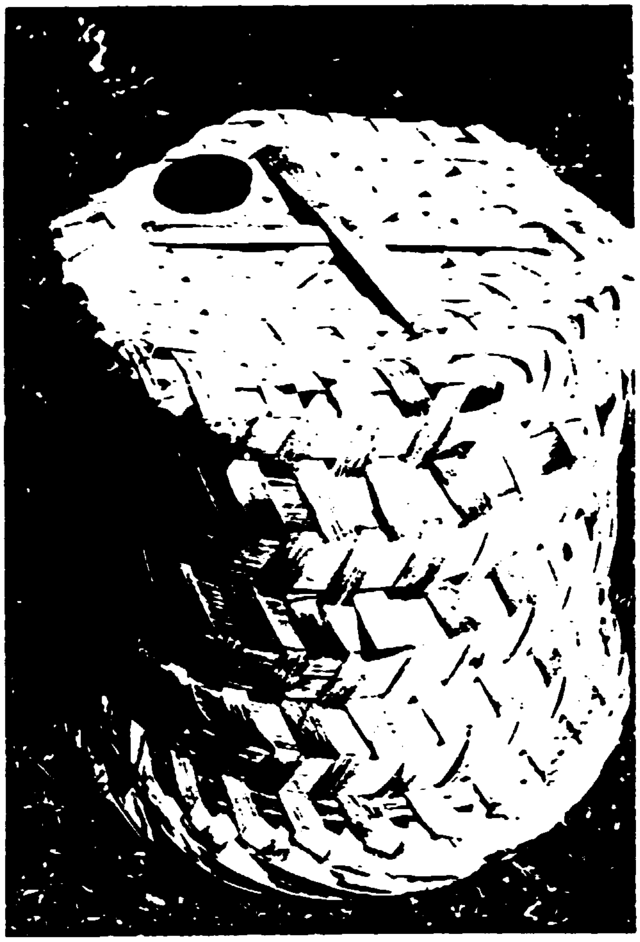
(Partial translation attached)

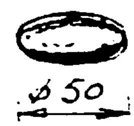
Photographic documentary



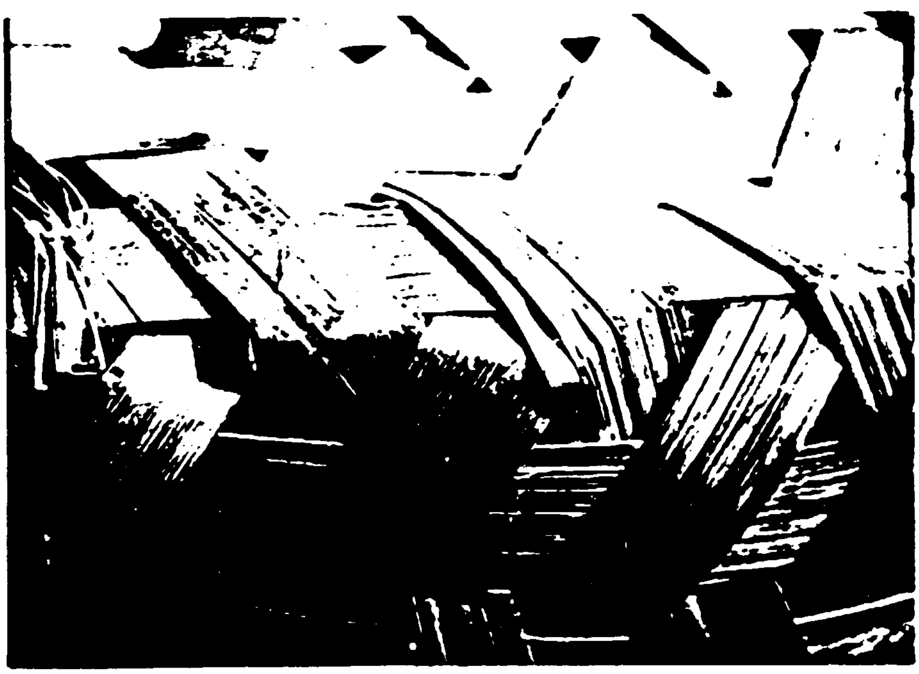
The traditional bamboo basket with capacity
of approximately 100 l with four handles

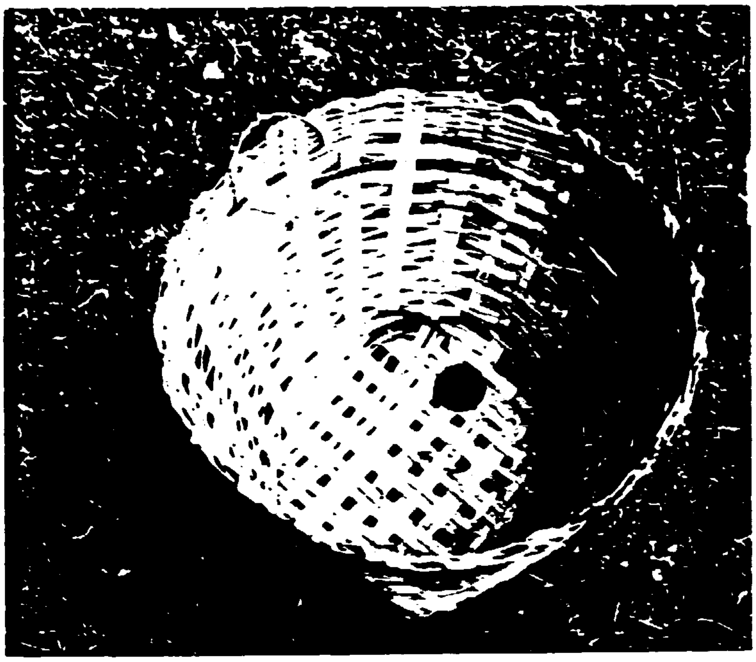


Smaller basket

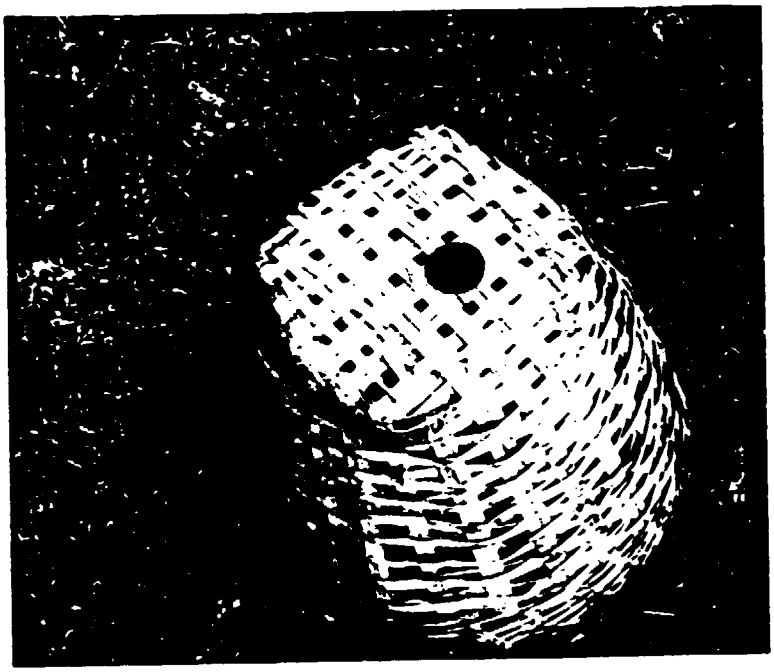


The bamboo is bent keeping good resistence

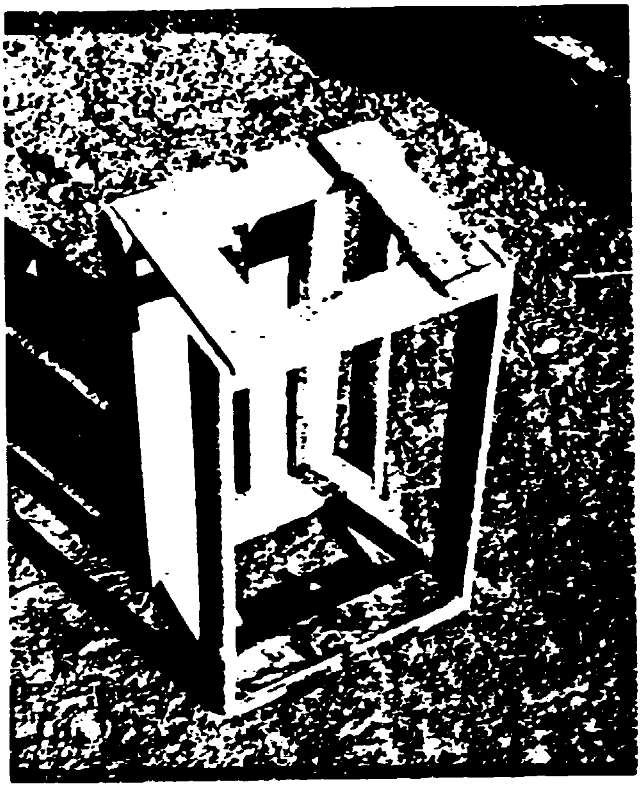




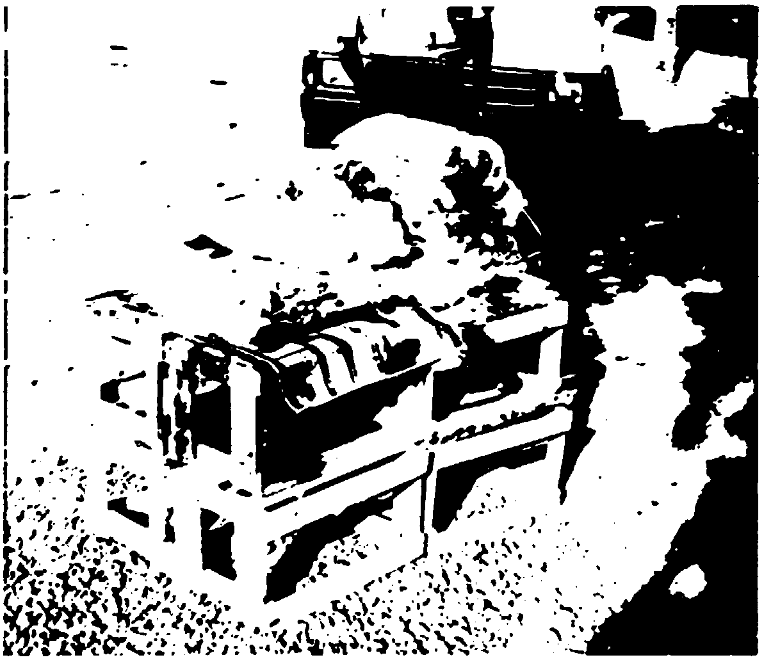
Basket with approximately 100 l



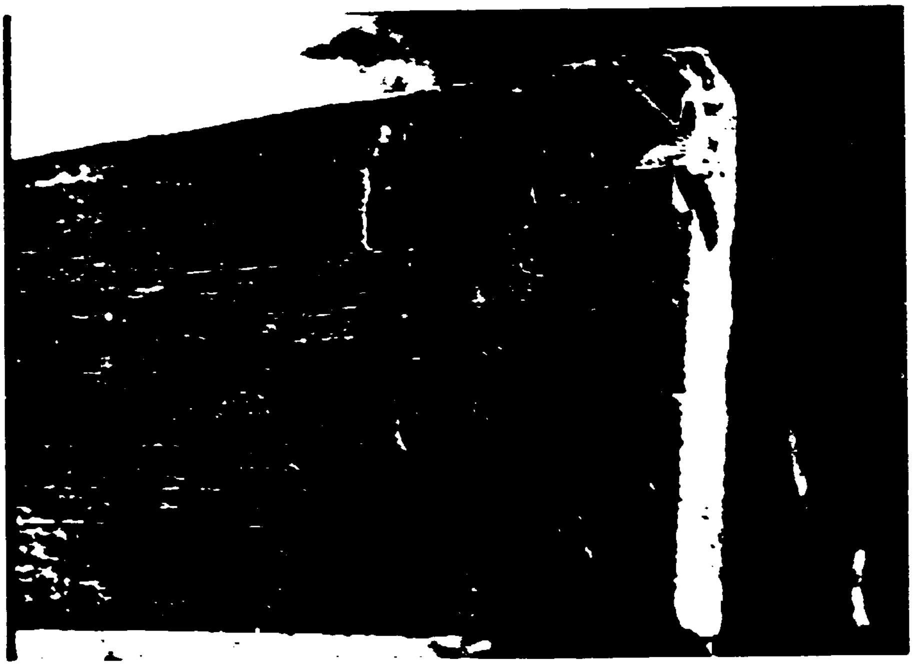
The bottom of the basket is damaged by chafing.



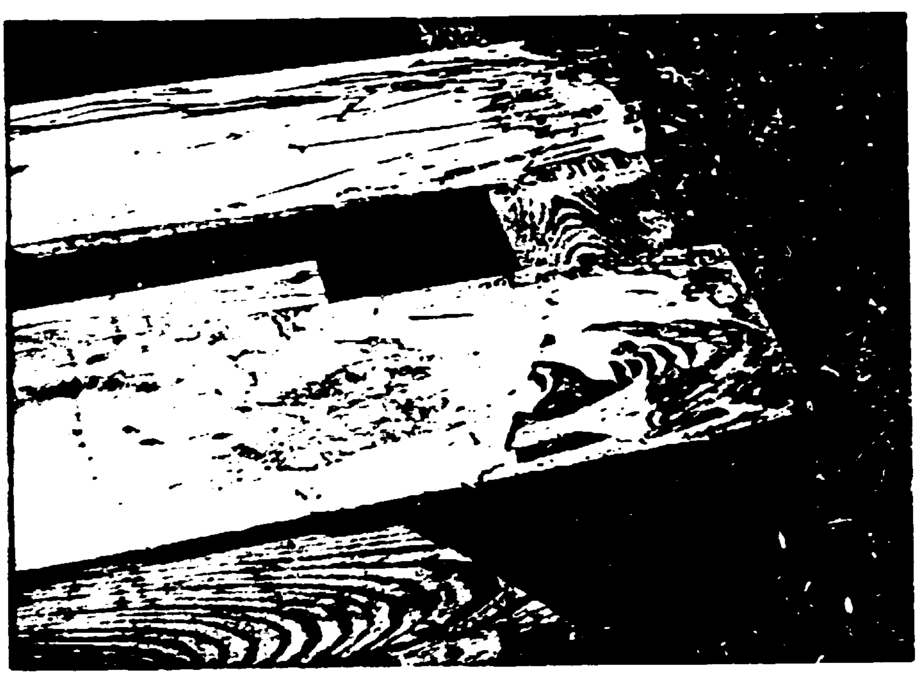
Boxes of rubber wood presently used



Street market in Nakhon Nayok

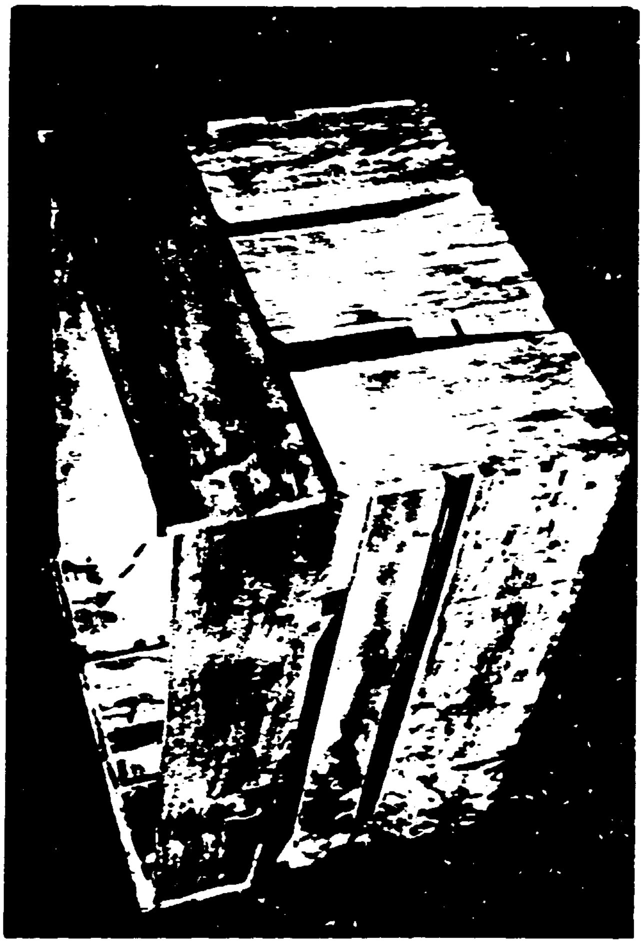


Rubberwood



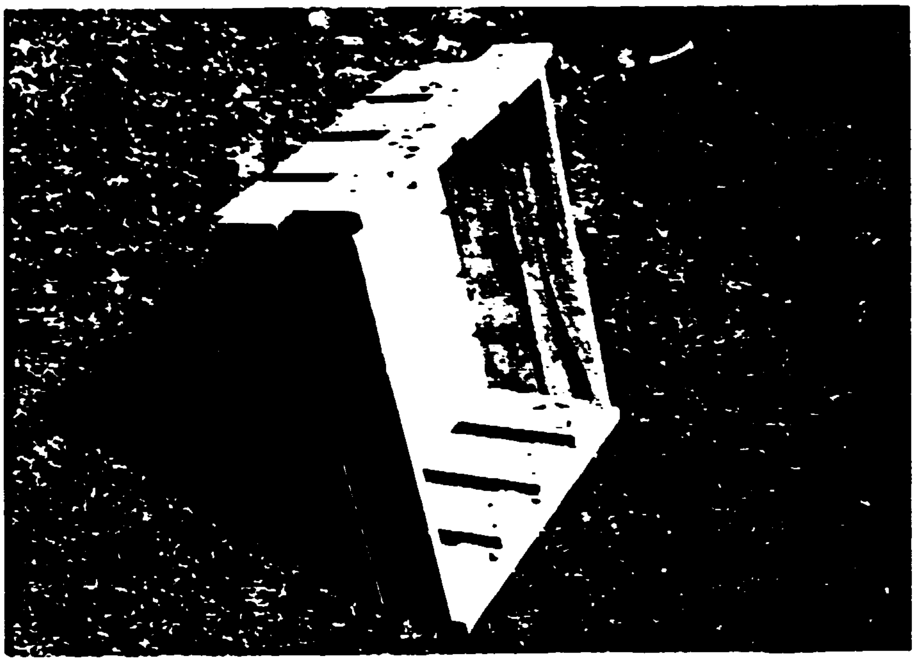
Pallet with mixed kinds of wood

Serious attacks by insects

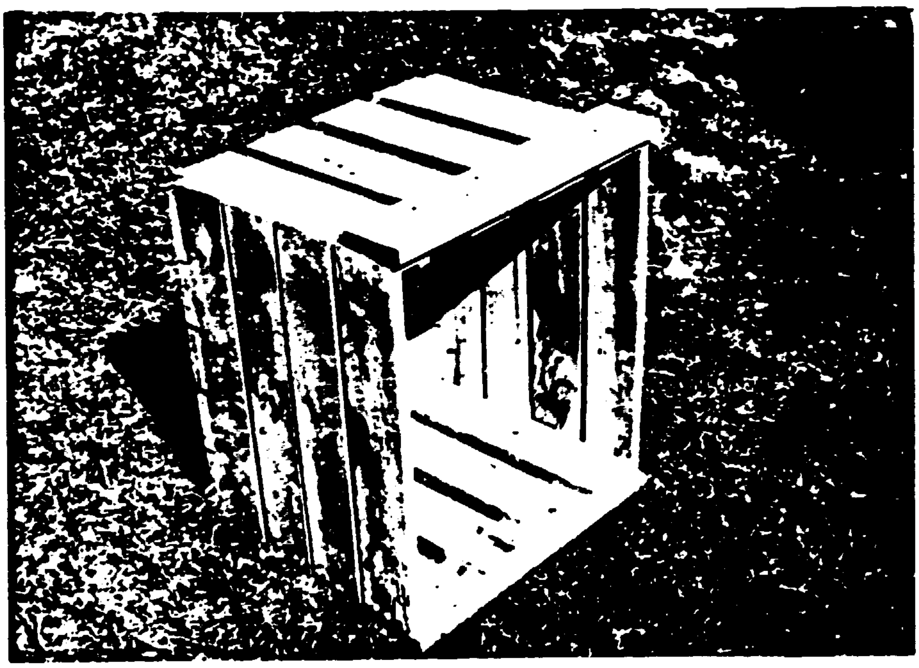


The C40 prototype

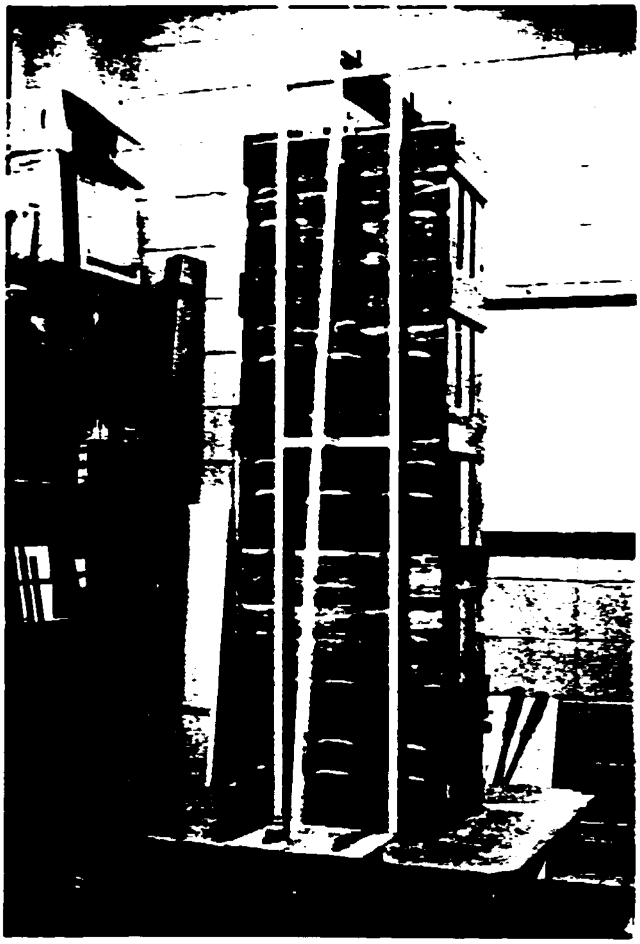
Boards are only 10 mm thick: nails too near the edge in 3 way corner



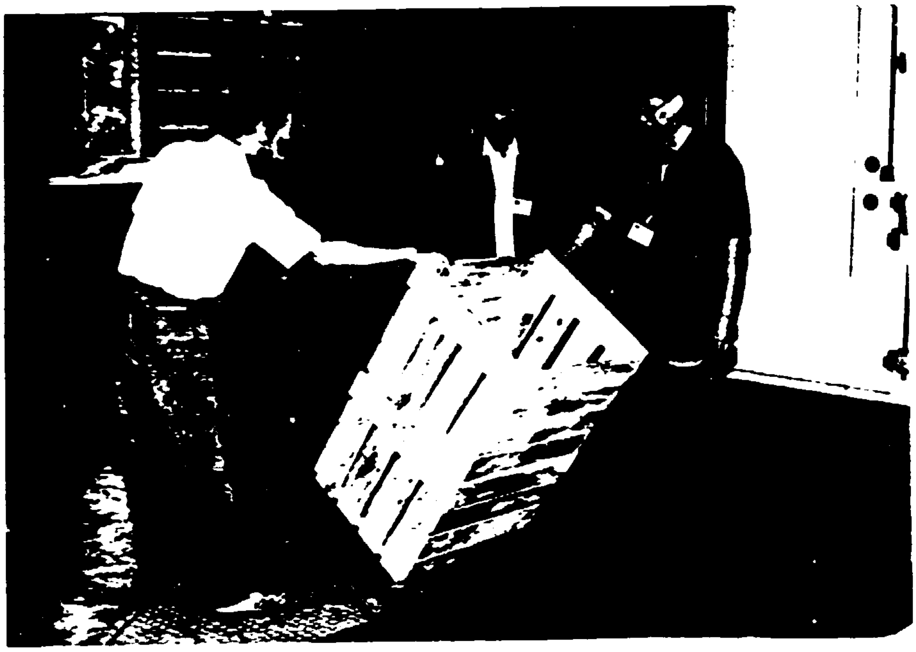
B50



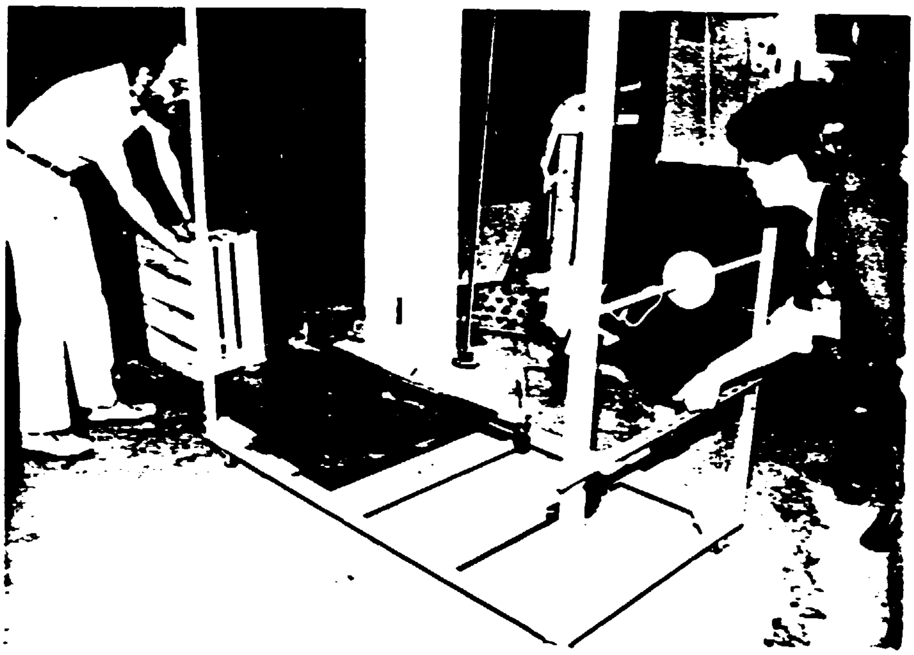
B100



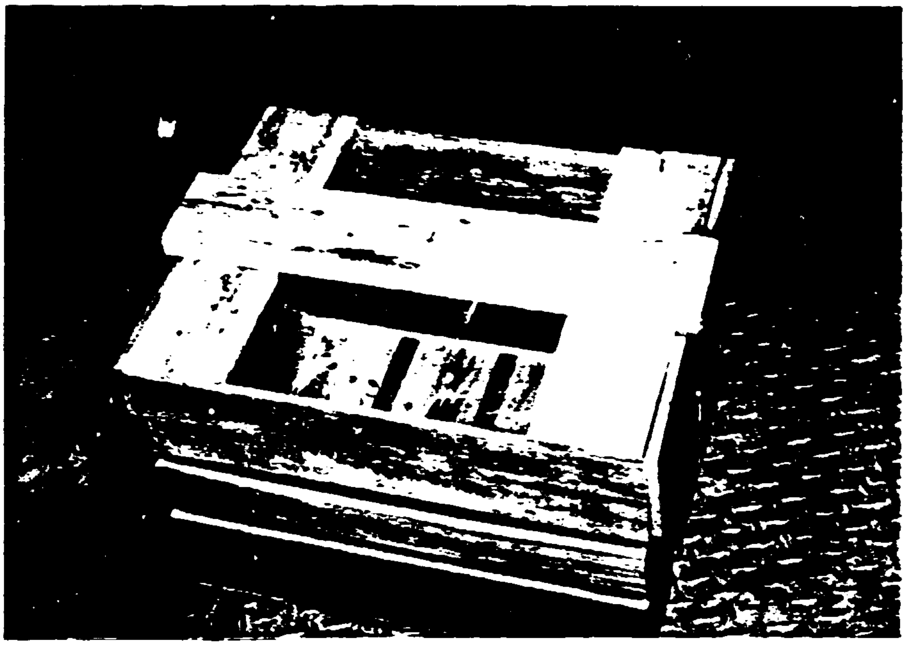
Boxes C40 in vibration and repetitive
shock test

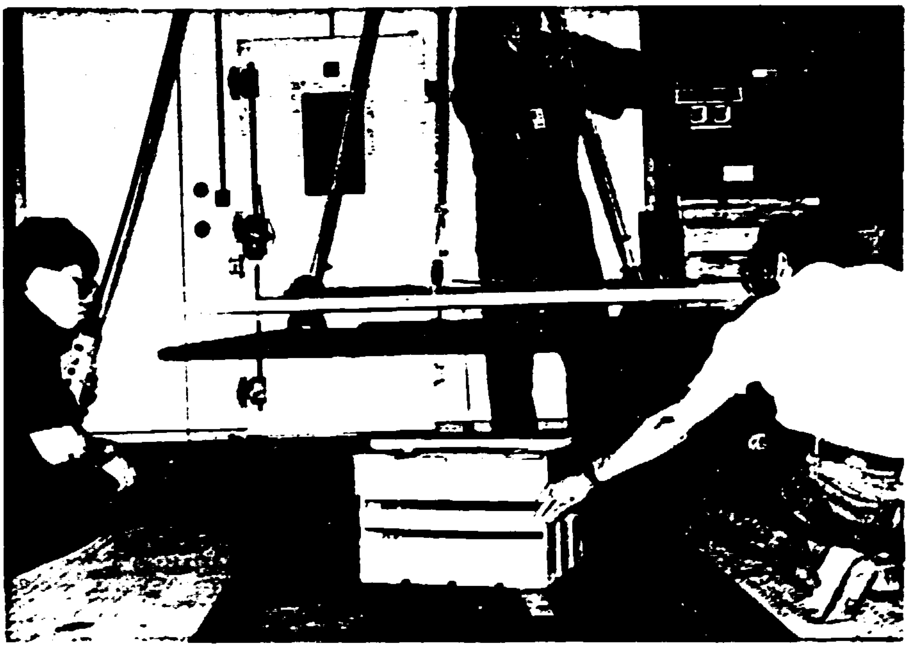


Stability of stack with B100 boxes
(empty and loaded, to see the
difference: small)

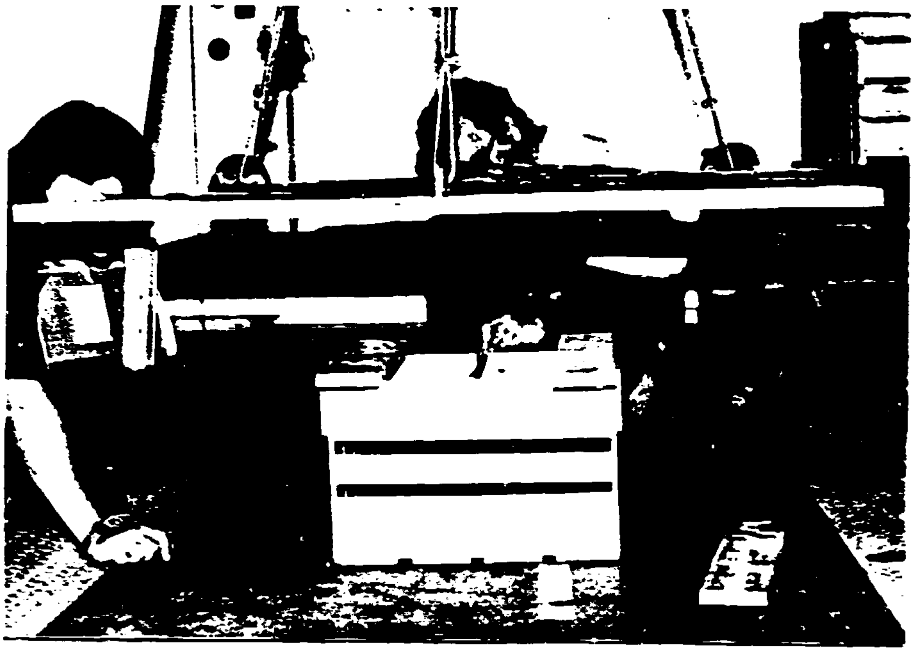


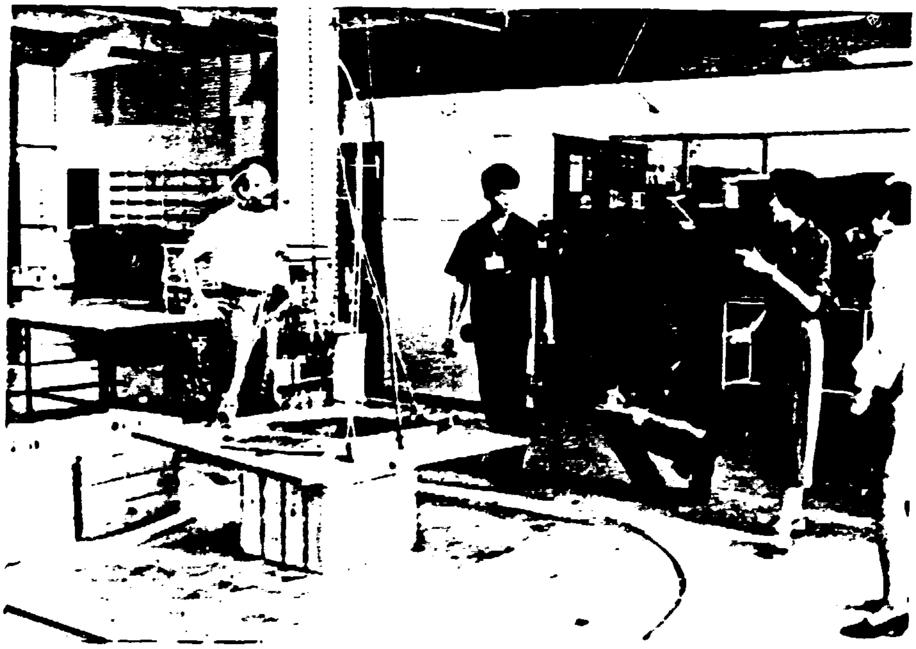
Puncture test using magnetic base as
release device
Pendulum too short





Adjusting the center of compression in box C40



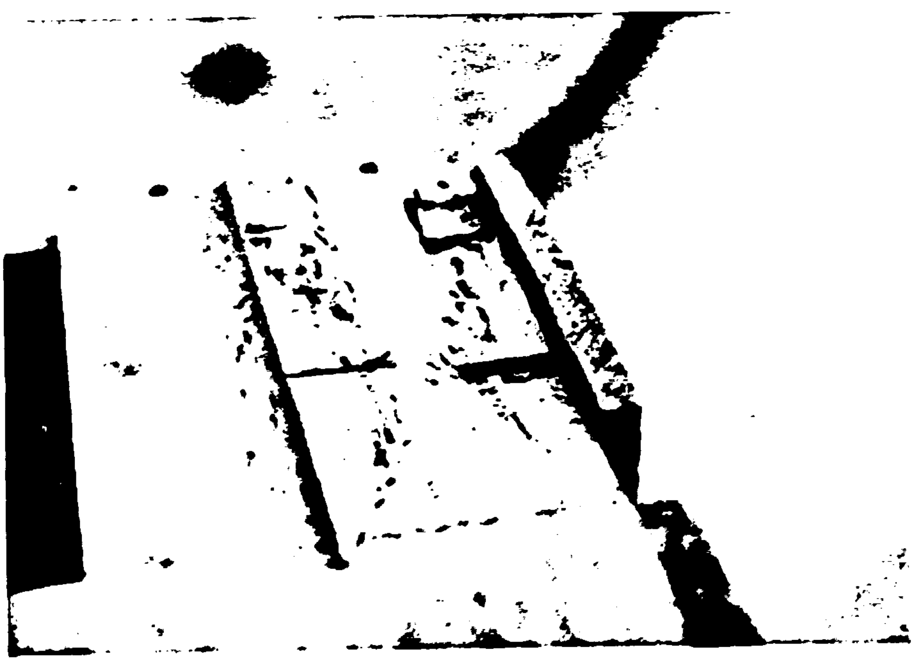


Compression tests of boxes
size C40 and B100

Drop test of box size C40.
Critical part is broken:
too thin for the nail

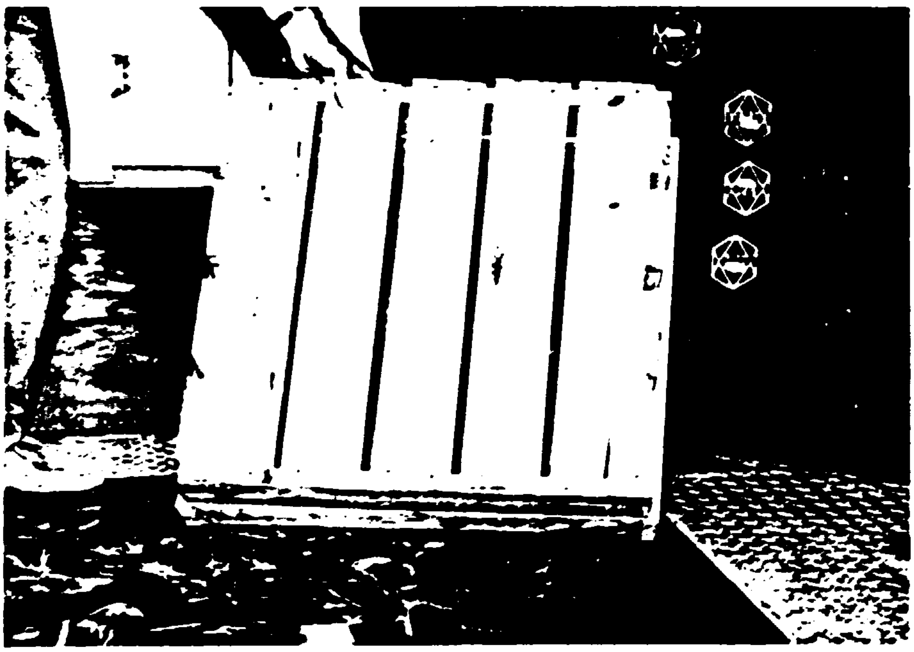
Drop test of box size B100

Drop test of empty boxes was introduced.

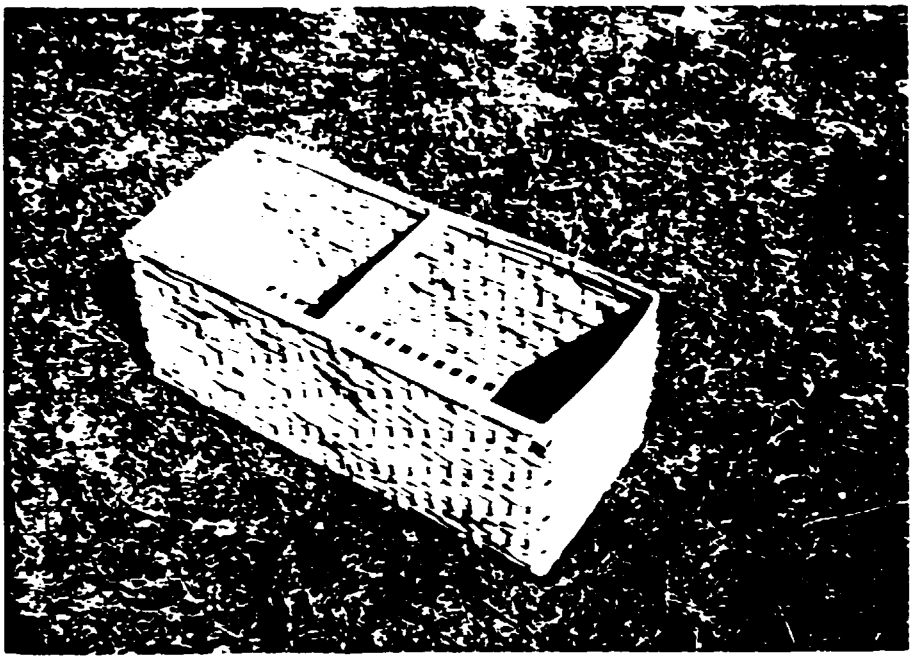


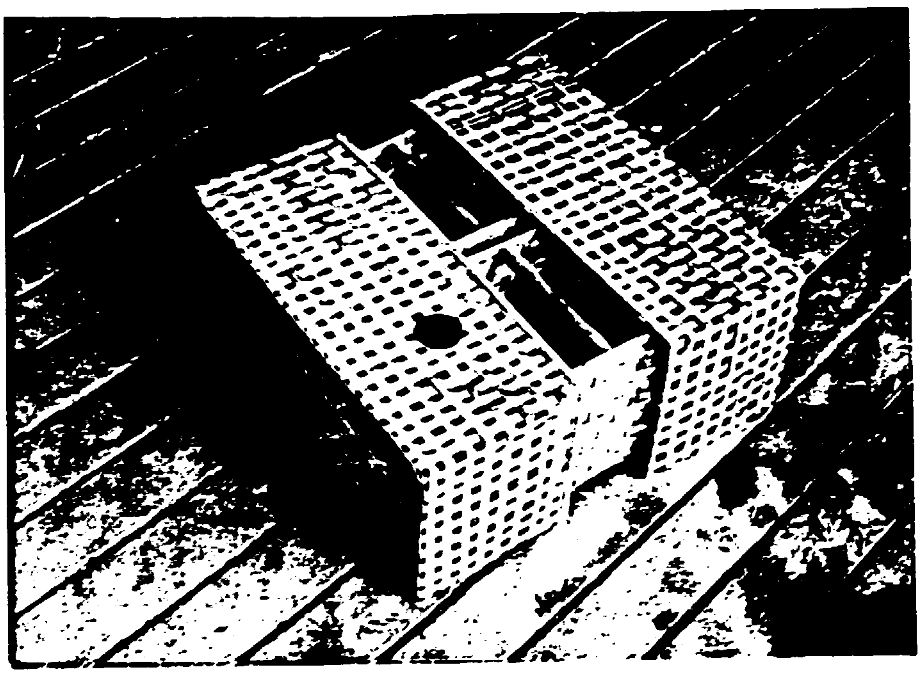
Box C-[illegible] damaged.

Drop test of empty B5[illegible] box.



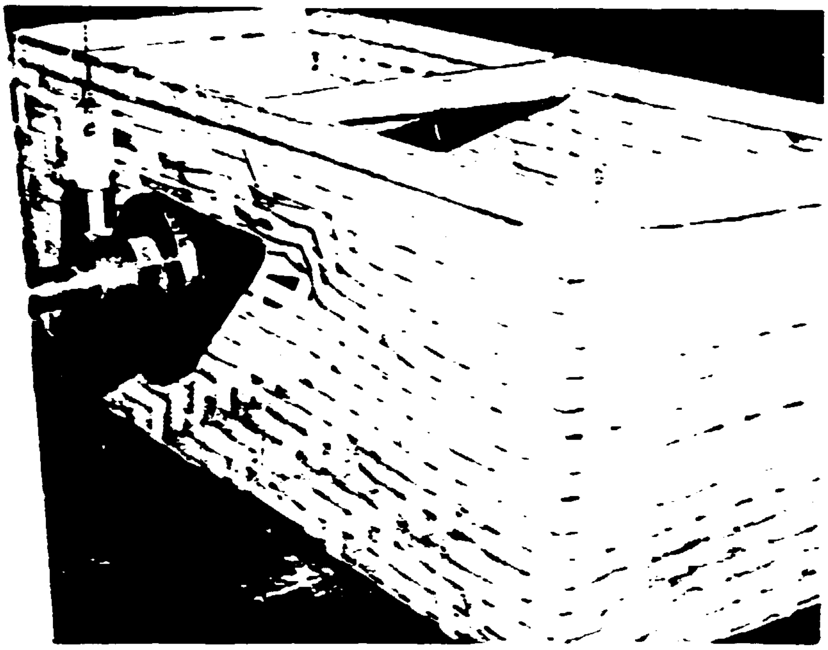
Racking deformation

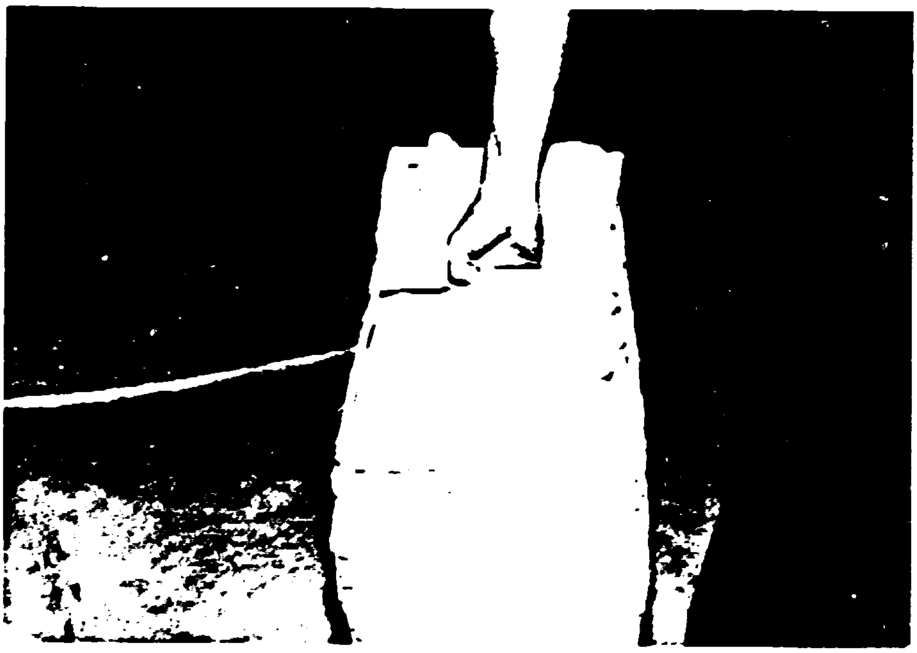




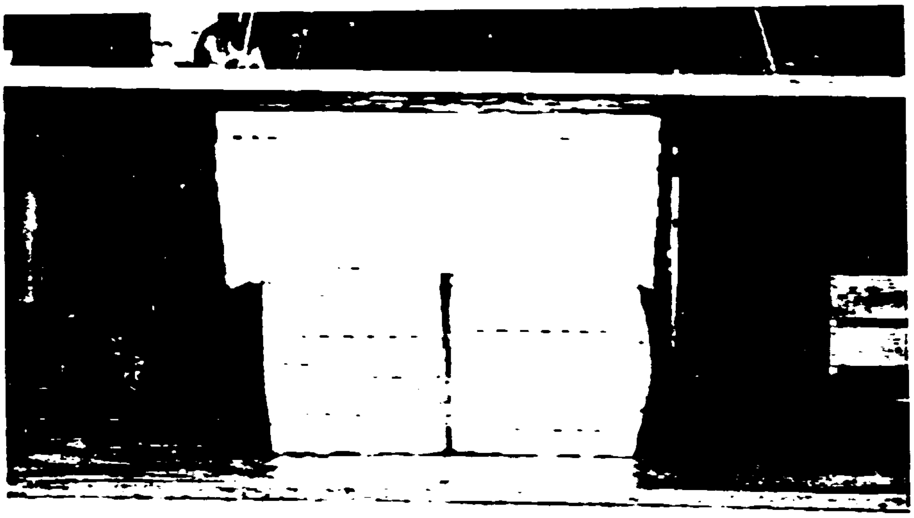
Interlocking to save space when empty

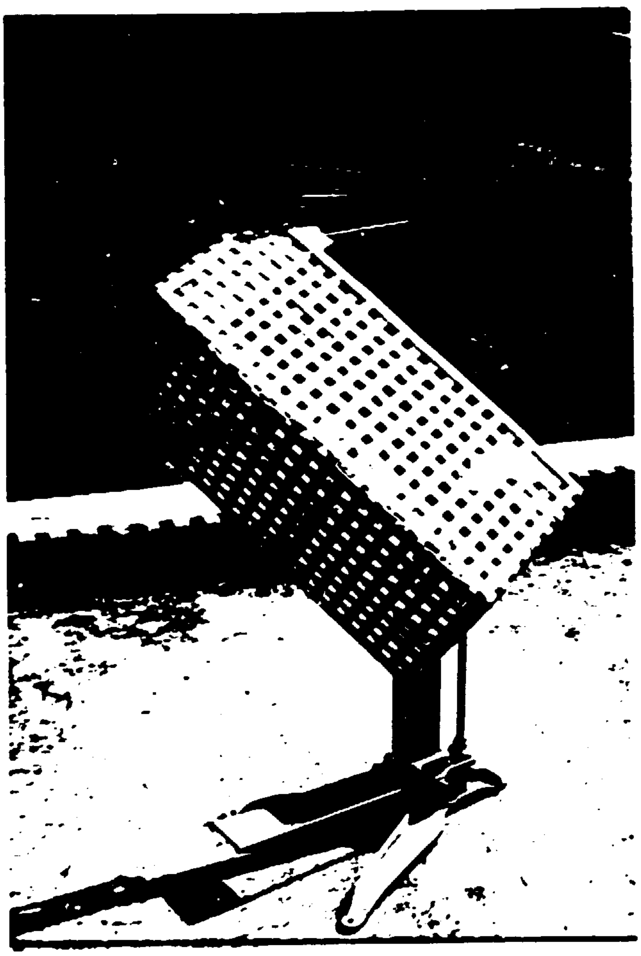
Baskets with closed and open mesh





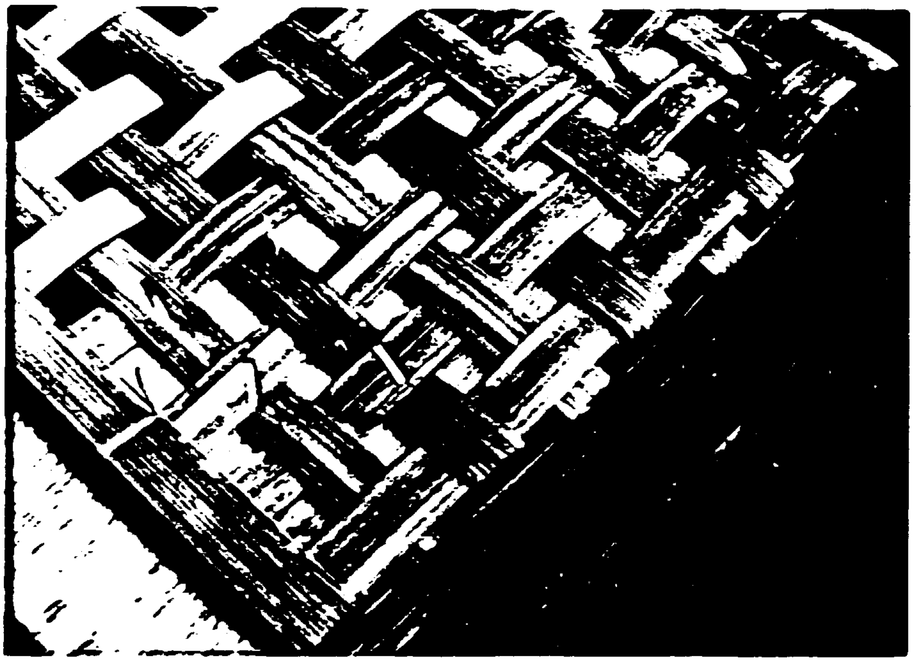
Puncture and manual lifting tests of baskets

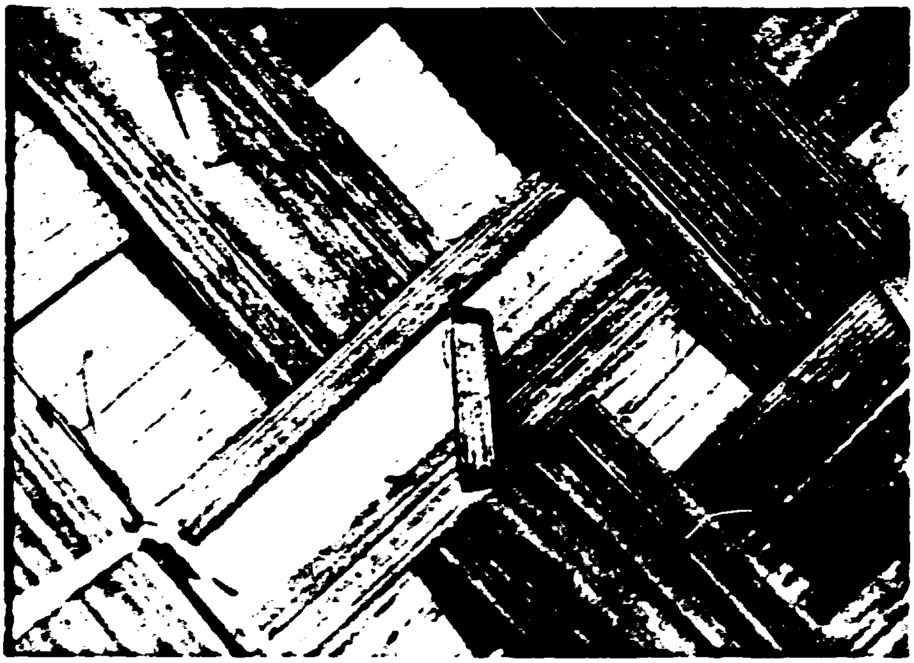




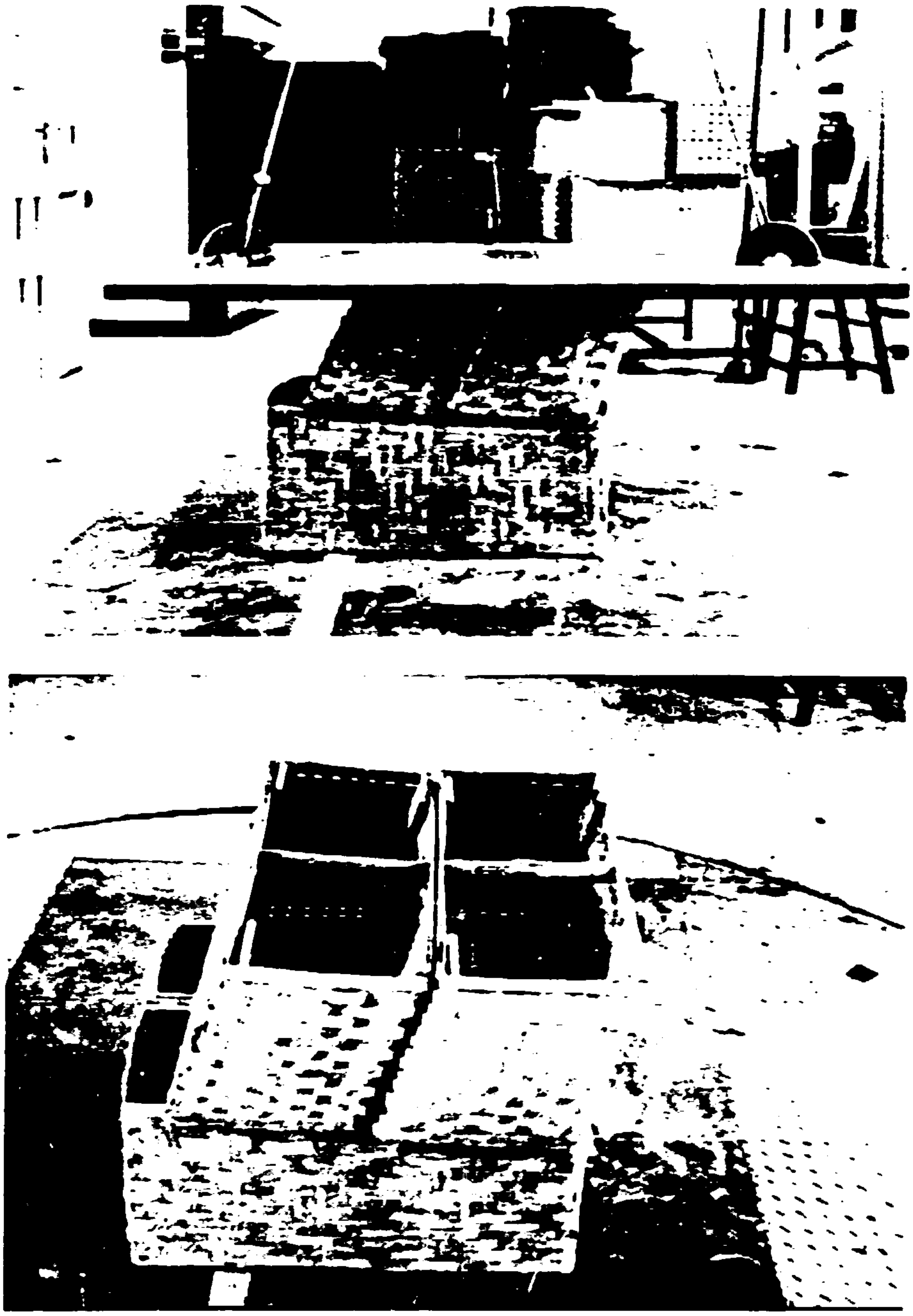
Bad results in compression test

Tentative of re-inforcing with stapled boards

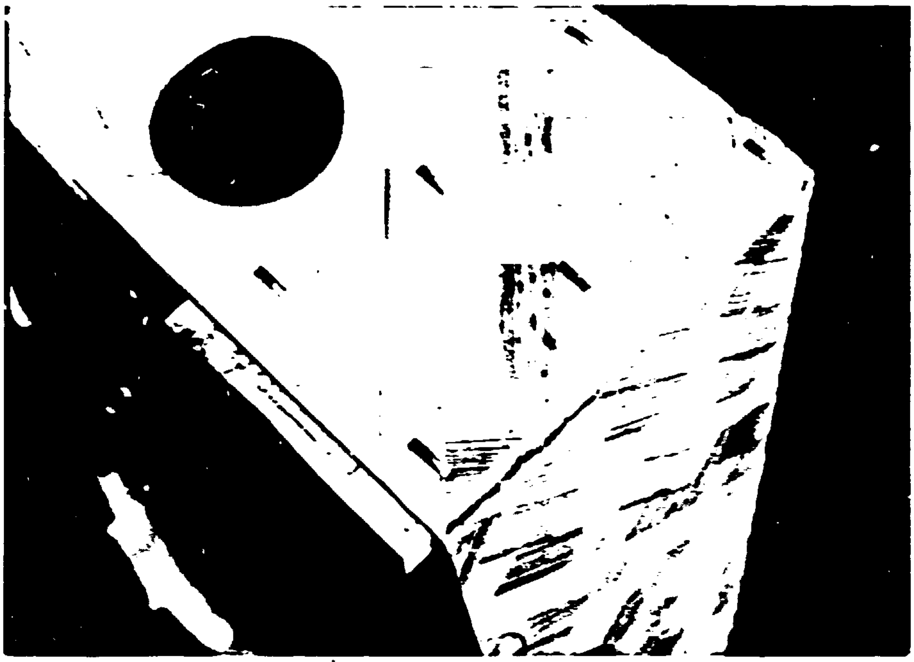




Staples are a good connection between bamboo and wood.



The "reinforcement" did not work!
To show that racking stability is important (see Figure 2).



Bamboo mat is very easy to staple on
board.

Problems of bending the corners are
still to be solved.

(Heating?)

MALAYSIAN TIMBERS – RUBBERWOOD

by

Rubberwood Research and Utilization Committee*

INTRODUCTION

RUBBERWOOD is the Standard Malaysian Name for the timber of *Hevea brasiliensis*. This species has been planted in Peninsular Malaysia for the past hundred years mainly for its latex. Though there is only one species of rubber trees planted in Malaysia, there are numerous clones that have been developed through the years. However, these clones are developed to achieve a higher yield of latex, and little has been done to improve the tree form or volumetric yield of wood from these trees.

Rubberwood trees are normally replanted after attaining the age of 25 – 30 years, when tapping for latex is no longer economical. At 25 years, rubber trees generally attain a clear bole of more than 10 metres tall (Westgarth & Buttery, 1965). Diameter of these rubber trees could easily reach 500 mm at breast height. However, trees of the newer clones are usually shorter and smaller. Boles of the seedling trees are usually strongly tapered.

DEFECTS

The logs are generally free from defects.

GENERAL CHARACTERISTICS

Rubberwood is a light timber with air-dry density averaging 640 kg/m^3 (40 lb/cu. ft.). The sapwood is generally not distinguishable from the heartwood. The wood is whitish yellow when freshly cut, and seasons to light straw or light brown with slight pink tinge.

The wood texture is even and fairly fine, with moderately straight and slightly interlocking grains. Latex can often be seen on the end surfaces, and the smell of latex is very distinct when the logs are being sawn.

WOOD ANATOMY

Growth rings are absent, although vague concentric markings can be observed on the cross section and these may simulate growth rings. These markings result in attractive growth-ring figures on the longitudinal surfaces. The vessels are big, moderately sparse, solitary and in radial groups of two to four. Tyloses can be found occasionally in these vessels. Wood parenchyma are abundant and visible to the naked eye and appearing as narrow and closely spaced bands, forming a net-like pattern with the rays.

Ripple marks are absent.

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* Forest Research Institute, Forestry Department, Peninsular Malaysia.
The Malaysian Timber Industry Board.
Rubber Research Institute of Malaysia.
Standards and Industrial Research Institute of Malaysia.

SAWING AND WOODWORKING

Rubberwood has been reported as easy to saw and machine (Lee & Lopez, 1980). A summary of these woodworking properties is given in Table 1. Sawing causes no significant blunting of the saw teeth. However, clogging of the saw teeth by latex is likely to occur during sawing. This clogging effect can be reduced by dabbing the saw blade with diesel fuel or kerosene during sawing.

Sawn boards warp easily due mainly to the presence of internal growth stresses and the juvenile nature of the material. Machined, either planed or turned, Rubberwood surfaces are smooth. Generally, the surface properties of air-dried boards improve with higher feeding speed, whereas for kiln-dried boards, a lower feeding speed is perferred (Sim & Mohd. Arshad Saru, 1980).

Lopez (1978) has reported that the resistance of Rubberwood to splitting when nailed is rated as good. Its resistance matches that of Sepetir *(Sindora* spp.), Mersawa *(Anisoptera* spp.) and Dark Red Meranti *(Shorea* spp.) and is better than Light Red Meranti *(Shorea* spp.) and Ramin *(Gonystylus* spp.).

Table 1: Woodworking Properties of Rubberwood

	Sawing		Planing		Boring		Turning	
Condition	Resawing	Cross-cutting	Ease of planing	Quality of finish	Ease of boring	Quality of finish	Ease of turning	Quality of finish
Green	slightly difficult	easy	easy	smooth	easy	rough	–	–
Air-dry	modera-tely easy	easy	easy	smooth	easy	rough	easy	rough

SEASONING

The timber generally dries slowly with rather severe seasoning defects. Although shrinkage is comparatively smaller than most Malaysian timbers, other dimensional movements such as bowing and twisting are more serious (Grewal, 1979a; Choo & Grewal, 1981). Choo & Grewal (1981) reported that with the stack weighted and a closer sticker spacing of 45 cm, bowing and twisting could be significantly reduced. A summary of the air-drying properties of Rubberwood is presented in Table 2

Table 2: Air Seasoning Characteristics of Rubberwood

Air-dry Moisture Content (%)	Shrinkage (%) Green to air-dry		Time to air-dry (days)		Remarks
	Radial	Tangential	25 mm	40 mm	
17.0	0.8	1.2	55-60	65-85	Timber dries with severe bowing and twisting. Boards void of pith are usually free of end checking and splitting

Shrinkage and drying rates of Rubberwood are found to be better than those of Ramin *(Gonystylus* spp.), Sepetir *(Sindora* spp.) and most of the Merantis *(Shorea* spp.).

Movement studies of Rubberwood show that it moves relatively little as compared to other timbers such as Light Red Meranti *(Shorea* spp.), Ramin *(Gonystylus* spp.) and Sepetir *(Sindora* spp.) (Choo & Grewal, 1981).

Employing Kiln Schedule E, 25 mm thick Rubberwood boards take about 6 days to kiln dry from a moisture content of 50% down to 10%. Degrade noted during kiln drying were similar to those which occured during air-drying (Grewal, 1979b). The boards are generally very prone to warping. Those containing pith split badly even before drying has started. Weighting down the stack and using closer sticker spacing, similar to that for air-drying, is recommended to reduce warping. Long period of pre-steaming and equalization treatment are also recommended for better kiln-drying recovery (Choo, 1981). Another important point is that during kiln drying, the wood produces some acidic vapour which is corrosive to the iron components in the kiln. Several charges in a row may cause extensive damage to the kiln. Kilns with aluminium parts have been successfully used to dry Rubberwood.

Table 4: Basic and Grade Stresses of Rubberwood

Condition*	Bending and Tension Parallel to Grain (Megapascal-)				Compression Parallel to Grain (Megapascals)				Compression Perpendicular to Grain (Megapascals)				Shear Parallel to Grain (Megapascals)				Modulus of Elasticity (Megapascals)	
	Basic	Select Grade	Standard Grade	Common Grade	Basic	Select Grade	Standard Grade	Common Grade	Basic	Select Grade	Standard Grade	Common Grade	Basic	Select Grade	Standard Grade	Common Grade	Mean	Minimu
Green	16.0	13.0	10.0	8.0	11.0	9.0	7.0	5.5	1.37	1.10	1.00	0.95	3.00	2.16	2.16	1.35	8600	6200
Dry	18.0	14.0	11.0	9.0	13.0	10.0	8.0	6.5	1.50	1.30	1.23	1.16	3.50	2.50	1.96	1.58	9140	6440

*1 Green stresses are applicable to timbers having a moisture content exceeding 19 percent.
2 Dry stresses are applicable to timber having a moisture content not exceeding 19 percent.

Note: The above table is derived from the data as recorded by Lee, *et al* (1979), using formulae as in Engku (1980a).

MECHANICAL PROPERTIES

Results of Standard Mechanical tests of the timber are as illustrated in Table 3. The basic and grade stresses of this timber have been worked out based on the formulae by Engku (1980a), and are presented as Table 4. The timber falls in Strength Group C following the criteria for strength grouping of Malaysian timbers (Engku, 1980b).

Results from steam bending trials have indicated that Rubberwood bends better than Kapur *(Dryobalanops aromatica)* and some of the White Merantis *(Shorea* spp.). Rubberwood bends are very stable after they are left to set (Ser & Lim, 1980).

Table 3: Strength Properties of Rubberwood*

Condition	Bending (Megapascals)	Compression parallel to grain (Megapascals)	Compression perpendicular to grain (Megapascals)	Modulus of Elasticity (Megapascals)	Shear Strength (Megapascals)
Green	58.0	26.0	3.65	8800	9.0
Air-dry	66.0	32.0	4.70	9240	11.0

*Source: Lee, *et al* (1979)

DURABILITY

Rubberwood in its natural form is classified as non-durable. It is very susceptible to attack by fungi and insects. Biodeterioration starts almost immediately after the tree is felled. Blue stain fungi penetrate the ends of logs within a week of felling and the infection is found to be more severe during the raining season (Hong *et al*, 1980). Ambrosia beetles attack the logs and Browne (1961) has recorded 16 species of ambrosia beetles attacking rubber logs.

Timber from rubber logs, before or after seasoning, is attacked by 7 powder-post beetles and one scolytid (Norhara, 1981). This attack is considered more severe as it renders the timber non useable.

PRESERVATIVE TREATMENT

Rubberwood is very amenable to preservatives. Normal treatment for boards involves mere dipping into tanks containing a preservative solution. Common preservative chemicals used are sodium pentachlorophenate (fungicide), gamma benzene hexachloride and borax (both insecticides). Other chemicals are also used such as captafol which can replace the more toxic sodium pentachlorophenate. This treatment, however, must be carried out almost immediately after the boards emerge from the saw. The resistance against biodeterioration could be enhanced by subsequent kiln-drying of the boards. Pressure impregnation with copper-chrome-arsenic compounds is seldom used to treat Rubberwood because of the undesirable greenish yellow colour produced by these preservatives.

POTENTIAL USES

The traditional belief that Rubberwood is weak and deteriorates too easily hinders wider applications. Hence, for decades, the only use of Rubberwood remains as a source of thermal energy; either in the form of domestic firewood, as fuel for drying kilns in the rubber, tobacco and brick manufacturing industries or converted into charcoal for the steel industry. Rubberwood has also been chipped for the pulp and paper industry.

However, from the strength point of view, Rubberwood satisfies the requirements for most applications except for construction. Its durability could also be improved by preservative treatments.

Though Rubberwood is not recommended for structural application due to limitation such as strength and available sizes, Rubberwood will be a good supplement to other fields of utilization. Rubberwood is utilized for furniture making, blockboard cores and parquet. It is also a potential raw material for the manufacture of chipboard, fibreboard, cement board and other small utility articles.

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Papers discussed in technical meetings

IS AN PACKAGING INTERFACE

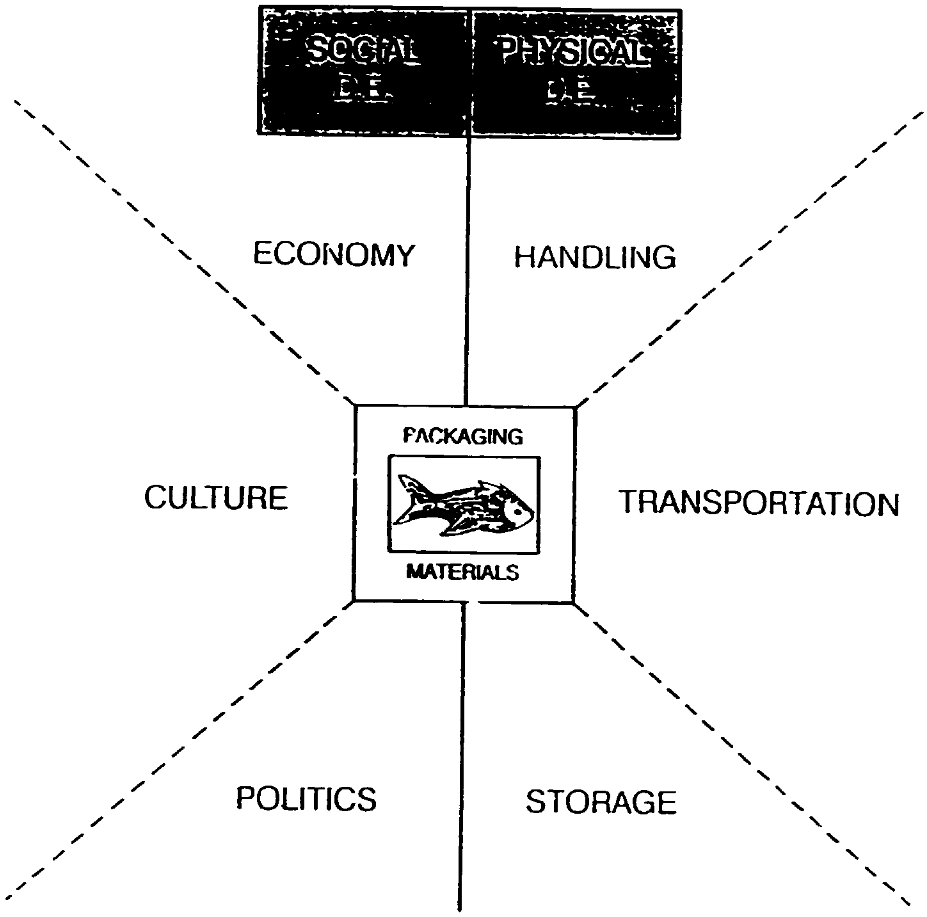
BETWEEN THE PRODUCT

AND THE DISTRIBUTION ENVIRONMENT

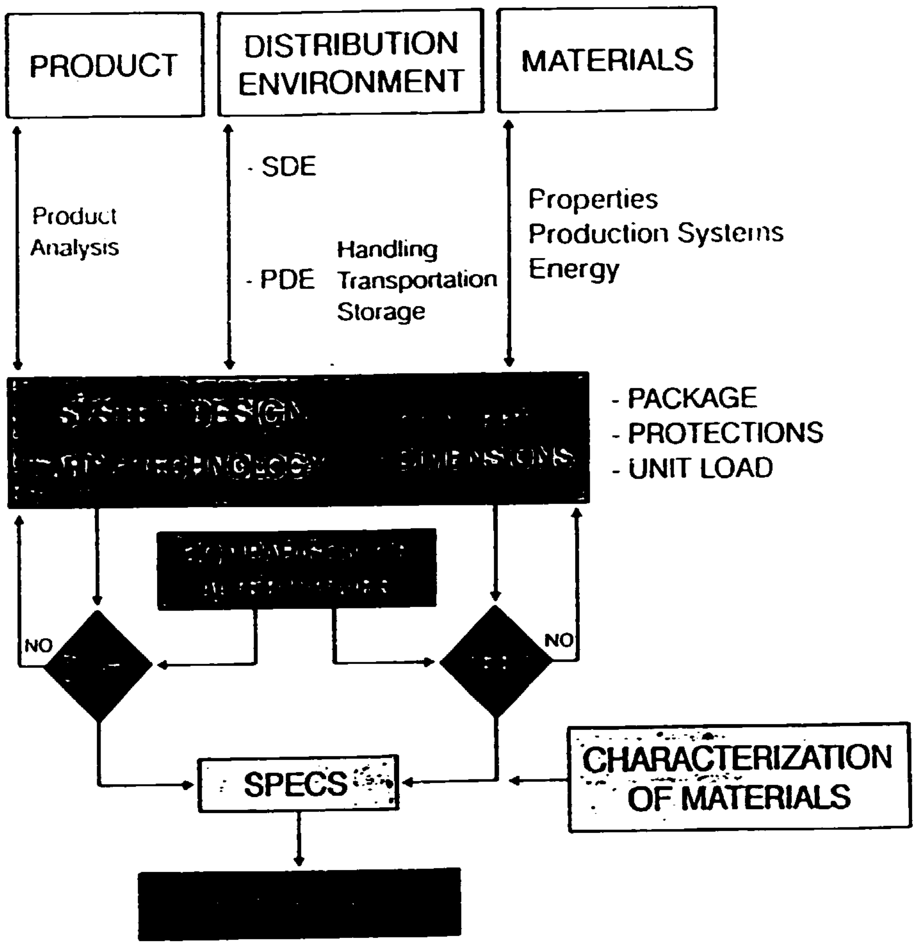
WITH FUNCTIONS

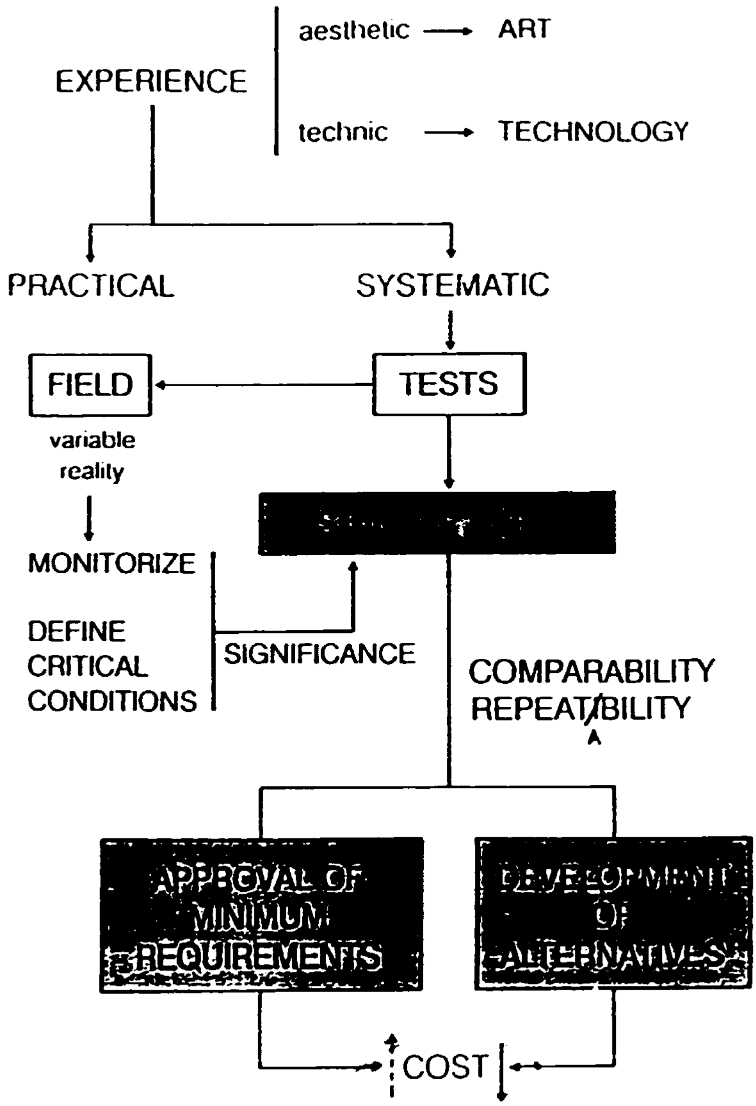
OF
CONTAINMENT
PROTECTION
COMMUNICATION

AT A MINIMUM TOTAL COST



Marketing
Legislation
Consumer rights
Consumer environment
Disposal environment


PRODUCT
DISTRIBUTION ENVIRONMENT
MATERIALS
Product Analysis
- SDE
- PDE
Handling
Transportation
Storage
Properties
Production Systems
Energy
- PACKAGE
- PROTECTIONS
- UNIT LOAD
NO
NO
SPECS
CHARACTERIZATION OF MATERIALS



EXPERIENCE
aesthetic → ART
technic → TECHNOLOGY
PRACTICAL
SYSTEMATIC
FIELD
TESTS
variable reality
MONITORIZE
DEFINE CRITICAL CONDITIONS
SIGNIFICANCE
COMPARABILITY
REPEATABILITY
APPROVAL OF MINIMUM REQUIREMENTS
DEVELOPMENT OF ALTERNATIVES
COST

GENERAL CONCEPTS ON

PACKAGING AND DISTRIBUTION

Packaging is an interface between the product and its distribution environment, with functions of containment, protection and communication which must be fulfiled at a minimum total cost.

We have to analyse the terms of this definition.

The distribution environment may be divided in two fields: physical distribution and social distribution. The physical distribution environment has aspects of handling, warehousing and transportation. The social distribution environment has economical, cultural and political aspects determining legislation and marketing.

The function of containment may be divided in a direct containment by the primary package, in contact with the product, and by secondary and tertiary containments constituted by the transport package and the cargo unit. The cargo unit is not exactly a package since it is not an interface with the distribution environment but only with part of the physical distribution, where pallets and cargo containers, for instance, are important.

The function of protection usually means the protection of the product against the environment. In the case of dangerous products, it has also the meaning of protection of the environment against the product.

The function of communication also has a double signification: that of objective communication through the information printed on the package, and that of subjective communication, that makes the package more or less attractive, used in promotion of sales and in the aesthetic quality of the cultural environment.

Packaging has also relations with other environments, besides the distribution: the industrial production environment, where it is born; the environment of use of the product, which sometimes gives other functions to the package, and the final destination, after use.

The functions determine specifications.

Quality is the conformity to functional specifications.

The design of packaging is a search for conformity to functional specifications, a search for quality at a minimum cost.

The design has three aspects: the conceptual, the dimensional and that of presentation.

The conceptual design defines the type, form, constructive details and materials of the package. It is the architecture of packaging.

The dimensional design is the determination of dimensions of geometry, of structure and of protections. It is the packaging engineering, based in functional specifications of performance. Performance specifications involve the geometry of the package, usually looking for the better use of space, and in a more usual meaning, the specifications of performance of structure and of protection systems.

The presentation design is related to the communication function in the levels of information, aesthetics and attraction.

The quality of a product is important to the final consumer or purchaser of this product. The quality of packaging, of the cargo unit and of the distribution system of that product are important to the responsible for the distribution. He has to assure that the product reaches the consumer keeping its quality, with minimum losses and damages to the product and to the environment, with maximum economic efficiency.

The quality of a package is important to the consumer of the product not only in regard to its functions in distribution but also for eventual functions in the consumption environment: easiness to open, to remove the product and to close, keeping the remaining part of the product in good condition; adequate use of space in shelves, in refrigerators. Aesthetic qualities are important for the packaging of certain consumer goods such as fragrances, and may not be so meaningful for industrial packages.

Quality is achieved at a certain cost. There is no reason in having a product, or its package, of excellent quality if this is achieved at a cost that makes the sale difficult or impossible. Then packaging must have a minimum cost compatible with its quality or functional specifications. These specifications depend on the foreseeable conditions of social and physical distribution environment, and in some cases, of consumption environment.

In a refrigerated distribution, for instance, milk may be packaged in plastic pouches. If the environment is not refrigerated and the purchase power of customers is high, aluminium laminated cartons may be used, with good shelf life. Considering low income populations even the product has to change: powder milk in plastic bags has the lowest cost of packaging and distribution.

The minimization of total cost is a process of comparison of alternatives with certain functional specifications. In a general case, it involves alternatives of design of the product itself, of its package and distribution system. Sometimes small changes in the product lead to considerable savings in packaging and distribution. In the most frequent cases, however, we can consider the product and the distribution environment as invariants in relation to different alternatives of packaging. These alternatives, then, are subject to the same series of tests related to performance specifications, and the approved package with the lowest cost is selected.

The minimization of economic costs depend also on a process of restriction of alternatives through the rationalization of patterns, generating economies of scale in production and distribution. Standard pallet sizes, for instance, or standard bottles.

The minimization of costs depends, then, on technical standards both to compare alternatives by testing and to restrict alternatives by the rationalization of patterns.

The standardization of tests, besides this economic function, has also the function of certification of conformity to specifications, without any comparison purpose. A certification of quality is a certification of conformity to functional specifications. This certification has different levels of reliability, being based in the test of a small sample or in a comprehensive quality assurance system.

Tests are not necessarily standardized. Field tests are usual and sometimes the only possibility. They loose, however, the repeatability necessary for comparison of alternatives and certification. They may be more realistic but this is meaningless if the physical conditions of the real enviroment is always changing, like in transportation, for instance.

Monitored field tests are second best to standardized tests. Accelerations in a truck, humidity in a warehouse, may be recorded and analysed in face of results observed in the tested packages.

Monitorized tests are a very important source of data for standardization.

Field tests may combine observations both in the physical and social distribution of pilot lots of a certain product. Marketing trials are used to test the reaction of consumers to a specific product and its package. Of course a set of rules is necessary for these tests and they may be considered technical standards, in broad sense. Technical standards are necessary for the calibration of monitor instruments, like accelerometers, for instance.

Besides the application in packaging, both in field and in standardized tests, both in development and in certification of quality, standardization of tests is important in the quality control of materials as well.

What is more important in quality control of materials is the correlation of the property under control and a significant functional quality of the package. This is quite obvious but, in practice, tests with very little significance (even meaningless) are used, like basis weight and burst of paper and corrugated board.
Standardization, specially of tests, should be based in research. An invertigation of typical conditions of reality and of procedures to

reproduce these conditions is the basis for performance tests standards. The correlation between performance of packages and properties of their materials is the next thing to be studied.

National standards should also be based in research. Even if an international standard or a foreign one is adopted, besides the problem of translation and terminology, the technical validity of this standard, specially in particular conditions in the country, must be studied.

International standards are not always correct. But, together with the standards of the more developed countries, they are a very useful reference in the creation of national standards.

The reality of the physical distribution environment is basically universal, with some differences in climatic conditions and availability of mechanical handling equipment. So, sharing of experiences between packaging laboratories of different countries is of real value.

TESTING AND EVALUATION OF PACKAGE PERFORMANCE

The Technological Research Institute of S.Paulo State (IPT) is in the campus of S.Paulo University, being both under the Secretary of Science, Technology and Industrial Development . It has 9 divisions, including the Division of Transportation Technology. This division has a Department of Logistics and Packaging, with a Laboratory of Packaging and Cargo Units (LEA-Laboratório de Embalagem e Acondicionamento)

The LEA works, since 1973, in the development, application and diffusion of technology of packaging and cargo units. It has a close co-operation with other divisions of IPT dealing with technology of materials and intensive relations with external organizations, like the Brazilian Technical Standards Association (ABNT), the Society of Packaging Professionals (EMBALA) and the Food Packaging Centre of the Food Technology Institute (CETEA-ITAL).

In the area of R&D, LEA is engaged in the improvement of techniques of design and quality control of packaging and cargo units. This leads to works in software and in standardization, specially of test methods and specifications.

More than 60 IPT LEA standards were developed, based in experimental research, besides theoretical and bibliographic studies.

Some are now recognized as Brazilian Standards (NBR). They are listed in appendix.

Important to discuss here are the criteria followed to reach the proposed standards. We have different kinds of standards: packaging performance specifications, performance tests and evaluations[1], tests and evaluations of material properties, standards related to pallets, cargo containers, methods of calibration of instruments, etc.

Our attention will be focused here in the performance specification and testing of packaging.

Standardized tests must be :

- repeatable
- sensitive
- representative
- simple to perform

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(1) We have two different words in portuguese to distinguish experiments with qualitative or quantitative results ("teste" and "ensaio", respectively), which control attributes or variables. For this reason we discriminate here "test" and "evaluation"

Repeatability is important for comparison of alternatives. The vibration of a truck, for instance, does not depend on the particular design of different alternatives of packages being carried (considering small variations in weight). The test conditions then must be the same, with the same vibration of all alternatives in comparison. This is obvious, but it is not the ASTM approach, for instance.

Certification also, requires a repeatability of tests, even in different laboratories, different industries and countries.

Sensitivity of a test means that it must not give always the same result for any package of a series of alternatives.

The representativeness of a test means that it gives to a package conditions very similar to certain critical conditions it would meet in its relation with the environment and with the product. This is the most difficult point in standardization of tests. The definition of critical conditions of the distribution environment is always subject to discussion. First because the reality is not a constant and second because it has a statistical aspect, difficult to evaluate.

Take the case of drop test for instance. If we plot the drop height as a function of weight of the package according to

ISO-BS, ASTM (two), AFNOR, JIS, DIN, NSTA, U.S.Fed.Spec., UNDG, some corporate standards, etc., we will have a cloud of points covering a large field. Some standards are even flexible - and this is very reasonable - defining two or three drop heights according to severity or assurance levels, generally related with the cost of the product or of the risk. Besides that, the function may not exist, and the same package may have different conditions of care.

The reality is also unforeseeable in the accelerations of a truck. Each truck, with a certain load, has predominant frequencies of vibration. Statistical analysis of a population of trucks lead to consider an envelope of all possible vibrations as a randomic distribution of intensities, with equal power density along the frequency range, so called "white noise". But a real truck, with real packages, is far from randomic vibration. So the present trend to use randomic vibration test, started with the american military standards, is wrong.

Since reality has this unforeseeable character the usual practice in engineering is the safety factor, which involves a certain ignorance factor. The evaluation of safety factors is always subject of discussion but some points are generally agreed upon. Values are integers, so a minimum value is 2. A maximum may be 4. In some cases the safety factor involves a dynamic factor due to accelerations in transportation, reaching then twice as much: 8.

It is interesting to analyse the compression test. Studies with corrugated board boxes are relatively precise in the determination of coefficients for the influence of humidity, duration of stack, misalignments, accelerations, in the compression resistance. But since these conditions are so difficult to forecast a safety factor is generally used. It should depend, however, on how much the reality is reproduced in the test. A static compression test with long duration, in controled high humidity - or high temperature in the case of plastics - is much more similar to the reality than a dynamometric compression test that takes few minutes in a press with paralel plates. Then safety factors may be 2 or 4 in each case. It is incredible that no safety factor at all is considered by a very important recommendation such as that of packaging for dangerous products of UN/ICAO/IMO.

The other point is the testing facility. Developed countries, that usually determine standards, don't pay much of attention to the cost of testing equipment and installations. Underdeveloping countries have to pay.

Some equipment, like climatic chambers and vibration tables are inevitably expensive but they would be much more if with strings attached to nice-to-have computers and printers.

It is not only the cost of investment (sometimes they are donations) but the cost - or even the impossibility - of maintenance, to be considered.

It is possible, anyway, and this is a problem for the packaging researchers of underdeveloping countries, to design test standards which require relatively low cost and reliable equipment. If this is true for package performance testing it is even more valid for quality control of materials.

A central laboratory, where packaging is developed in the benefit of the country or of a series of organizations, where research is conducted and standards settled, may have expensive and sophisticated equipment to a certain extent. Standards, on the other hand, have to be used by a large number of industries, some small ones, mainly for the quality control of materials. The low cost of equipment, then, is important in standardization.

Some test standards actually in use still require advance in research in relation to procedures and/ or to the intensities of conditions. It is again necessary to stress the importance of exchange of experience, or even cooperation in research, between the packaging laboratories of different countries.

In performance testing attention should be concentrated in few points: drop test, compression, vibration and repetitive shock.

<u>Drop test.</u> The procedures are simple and generally accepted but the drop height is still a point of controversy. Even stirring up the discussion it is suggested that, besides the three levels of severity, a distinction be made between operational and accidental drops. The drop of empty returnable boxes is also a new point to consider. IPT developed a proposal of standard, presently under consideration of a special commitee of the national standardization organization, for performance specification of boxes for wholesale distribution of fruits and vegetables, where suggestions are made of operational and accidental drops, of returnable and nonreturnable boxes. A standard for flexible intermediate bulk containers also was defined, recognized as NBR, where this concept of operational and accidental drops is used.

<u>Compression test.</u> A distinction first is made between static compression test and dynamometric compression resistance evaluation. In both cases research is necessary on the safety factors, already discussed. In the latter a problem of procedure is still pending. The compression between two parallel guided plates is completely far from the reality. An equipment like that of MTS, besides being more simple, allows the rotation and side shift of the upper plate in relation to the other, with much better simulation of a real stack. A revision of present standards is necessary in spite of the fact that expensive equipment (like that of IPT) would have to be transformed.

In relation to static compression a variable to be determined is the duration of load. If a safety factor is used which involves the dynamic factor, resulting then a very large value of load, a short duration of test is reasonable: 5 or 10 minutes. If the test has to verify the influence of humidity or temperature (creep in plastics, particularly), long durations are necessary: 24 or 240 hours. This test should be made in a climatic chamber or oven (60°C).

Another variable under study is the static compression test combined with shear load, simulating the racking of a stack in a truck with horizontal accelerations. Wooden crates are very sensitive to this kind of load.

Vibration test. A study was made at IPT in the early 80's, with the purpose of comparison of alternatives of boxes for tomato, the traditional wooden box and a new corrugated board box, with vibration in laboratory parallel to field tests, with trucks travelling distances of 100, 400, 1000 and 4000 km. This study was used also to compare different test standards. ASTM gave the best correlation between laboratory and field tests. An acceleration of 0.3 G was considered ideal and a certain correlation was found between distance of transportation and time in the vibration table: one sweep for each 100 km. A continuation of this study was made by E. Ardito of ITAL at Michigan State University and IPT. Further research is nevertheless necessary, also regarding the validity of sweeps with fixed amplitude of acceleration. A truck always has more intensive vibrations between 3 and 10 Hz, due to the suspension.

Repetitive shock. It is more complex to simulate than vibration, since it is function not only of the truck and road conditions but also of the position and lashing of the packages on the truck. ASTM and NSTA, for instance, are out of reality in this case since they do not simulate the stack condition. Dynamic compression and shock between packages are fundamental here. A study should be made of the correlation between test duration and distance of transportation. Tests with large home appliances (stoves, dishwashers, refrigerators) with 4 seconds for each 100 km gave good results in comparison with damages observed in real transportation, but this was not a systematic experiment. One of the main difficulties is to distinguish the damage in transportation caused by repetitive shock of that caused by vibration. Instrumentation of the truck and dynamic analysis of registered accelerations are necessary in this study.

Conclusions

Since cost and quality depend on standards the quality of the standards themselves is of fundamental importance. A program of research is necessary for standardization, involving packaging laboratories of different countries, even for the settlement of terms of competition in a fair trade, with better control of quality and safety.

ANNEX A - IPT STANDARDS ON PACKAGING AND PACKAGING MATERIALS

* S - Specification
T - Test
E - Evaluation

No. IPTLEA	Title	type*	NBR	Source
01	Packaging - Performance	S	9467	
02	Packaging - Drop	T	9474	IPT/ISO
03	Packaging - Normal static compression	T	9475	IPT/ISO
04	Packaging - Static compression with shear	T	—	IPT
05	Packaging - Handling	T	9476	IPT
06	Packaging - Vertical Vibration	T	9477	ASTM/IPT
07	Packaging - Horizontal shock	T	9462	ISO
08	Packaging - Horizontal oscilation	T	9463	IPT
09	Packaging - Puncture	T	9464	UNDG/IPT
10	Packaging - Concentrated compression	T	9465	AFNOR
11	Packaging - Repetitive shock	T	--	ASTM/IPT
12	Packaging - Low pressure	T	9466	ISO
13	Packaging - Internal pressure	T	9471	UNDG

No. IPTLEA	Title	Type*	NBR	Source
14	Packaging - Rain	T	9467	IPT
15	Packaging - Humidity	T	9468	IPT
16	Packaging - Dust	T	—	IEC
17	Packaging - Compatibility with the content	T	9469	IPT
18	Packaging - Leakage	T	9470	UNDG
19	Packaging - Fire	T	9472	UNDG
20	Packaging - Heat transmission	E	—	IPT/ISO
21	Containers - Capacity	E	—	IPT
22	Packaging - Instability	E	—	IPT
23	Cans and plastic bottles - Radial compression	E	—	IPT
24	Cans and plastic bottles - Radial compression	T	—	IPT
25	Packaging - Dynamometric compression	E	—	ASTM
26	Plastic bags - Capacity	E	—	IPT
27	Corrugated board - Rigidity	E	—	IPT
28	Corrugated board - Puncture	E	—	IPT
29	Flexible materials - Impact	T	—	ASTM/IPT
30	Flexible materials - Dynamic tension	T	—	IPT

No. IPTLEA	Title	Type*	NBR	Source
31	Self adhesive tapes - Adhesivity	E	--	Kodak/IPT
32	Cushioning materials - Shock	E	—	ASTM/IPT
33	Cushioning materials - Vibration	E	--	IPT
34	Wood - Dynamic hardness	E	—	ASTM/IPT
35	Materials - Eletrostatic properties	T	—	IPT
36	Flexible materials - Static puncture	T	--	IPT
37	Product - Sensibility to shock	E	—	ASTM/IPT
38	Product - Sensibility to vibration	E	--	IBM/IPT
39	Rigid pallet container - Hoisting	T	—	IPT
40	Rigid pallet container - Lifting by forks	T	--	IPT
41	Rigid pallet container - Impact	T	--	IPT
42	Flexible containers - Drop	T	?	BS

No. IPTLEA	Title	Type*	NBR	Source
43	Flexible containers - Compression	T	?	BS
44	Flexible containers - Lifting	T	?	BS
45	Pallet - Rigidity of face	E	8336	AFNOR
46	Pallet - Rigidity when supported by upper face	E	8337	AFNOR
47	Pallet - Rigidity when supported by bottom face	E	8338	AFNOR
48	Pallet - Shear	T	8339	AFNOR
49	Pallet - Impact against fork	T	8340	AFNOR
50	Pallet - Drop	T	8341	AFNOR
51	Pallet - Anticlastic vibration	T	—	IPT
52	Pallet - Central load	E	—	ANSI
53	Hand bag - Handle fatigue	T	—	IPT
54	Steel bobin berth - Performance	S	—	IPT
?	Funerary coffins - Resistence	S	—	IPT
?	Plastic films - Transparency	T	—	IPT
?	Garbage bags - Performance	S	—	IPT
?	Accelerometer - Calibration	E	—	IPT
?	Boxes for fruits and vegetables Specification	S	—	IPT
?	Packaging for dangerous products - Specification	S	?	UNDG/IPT

Translation (partial) of Brazilian Draft Standard on Boxes for Wholesale Distribution of Fruits and Vegetables (ABNT 23:01.07:001)

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5. Test specifications

5.1 Static compression

According to NBR 9475, simulating maximum stack height of 2300 mm in static and 1650 mm in transportation, apply the following formula:

$$T = \left(\frac{2300}{h} - 1\right) V \cdot k$$

where:

T = test load (daN)

h = height of box in stack position

V = volume of box in liters

k = 0.8 for light duty

1.0 for normal duty

1.2 for heavy duty boxes

Note 1: These values are based in a safety factor of 2 in static stack or 4 in transportation.

Note 2: In 2300/h consider only the integer value.

Keep the test load for five minutes.

5.2 Accidental drop of empty boxes

Reusable boxes, empty, should be submitted to four drops of 800 mm, in the position of Figure 3, with an impact at each corner, the diagonal being vertical.

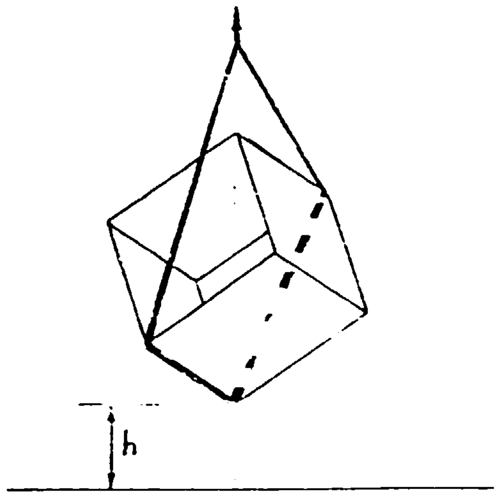

FIGURE 3

5.3 Operational drops

Follow NBR 9474 (6.126) with the specifications:

- Drop height: 100 ± 2 mm
- Position of impact: against the bottom corners, with one diagonal being horizontal, according to Figure 4.
- Number of drops:

  reusable boxes: 10 in each corner

  one way boxes: 4 in each corner
- Content:

  product similar to one of intended use for the box, with the following apparent density (in kg /dm^3):

Light duty	:	between	0.3 and 0.4
normal duty	:		0.4 and 0.5
heavy duty	:		0.5 and 0.6

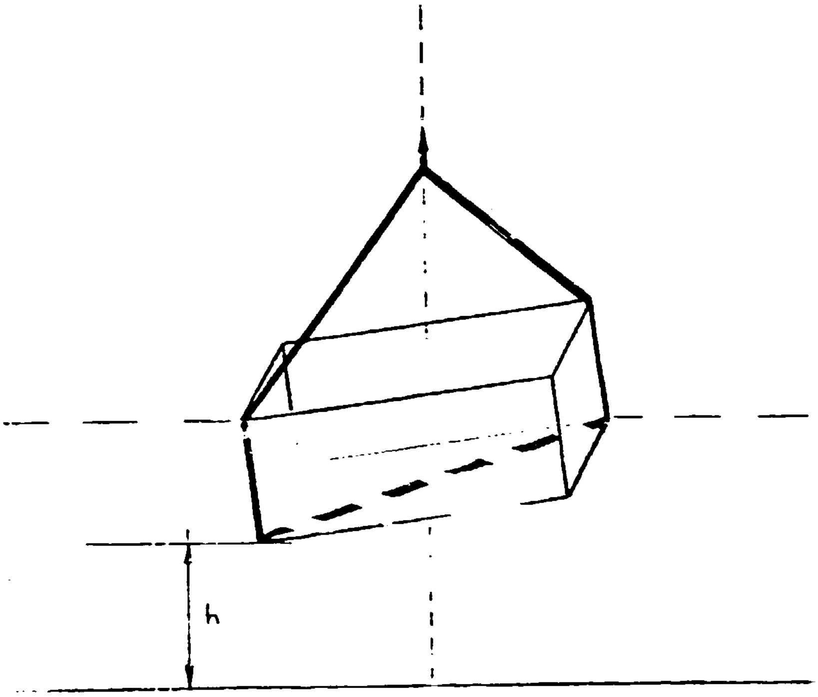

FIGURE 4

5.4 Lifting test

according to NBR 9476, with the following load

$$L = 2.d.v$$

where:

L = load (da N)

d = apparent density (in kg/dm^3)

light duty	: between	0.3 and 0.4
normal duty	:	0.4 and 0.5
heavy duty	:	0.5 and 0.6

v = volume of the box, in dm^3

5.5 Stability of stack

Superimpose to boxes, with the content, over a rigid board apt to be submit to an inclination, fixing to it the bottom box.

Increase the inclination up to 40° (with the horizontal). The upper box should not slide.

5.6 Localized impact

Impact a steel ball with a diameter of 50 mm, with a free fall of 1 m, against any point of the box. No damage should occur.

Backstopping officer's comments

The present two-month mission of the expert is a follow-up of his one-month mission, which took place in May 1990.

During the first one-month mission, the expert elaborated guidelines for the development and laboratory testing of packages for fresh fruits, vegetables and marine products, and developed the design of a few new prototypes of alternative packages for the same products, to be made out of indigenous materials with the utilization of low cost equipment.

The technical report DP/ID/SER.A/1367 was produced after the first mission of the expert and distributed to the authorities concerned. In the report it was clearly stated that the second part of the mission would be mainly focused on an analysis of the alternative package designs, further development of their specifications and manufacture processes, transport packages wood treatment and laboratory evaluation methods as appropriate.

The present report shows that the second phase mission, which actually took place from December 1991 to January 1992, was carried out in line with the main objectives referred to above.

In this connection the expert made general observations and proposed revised specifications for the transport package prototypes which had been elaborated previously, not only in light of the local experience but also of the research work which he had carried out meanwhile at his own laboratory at IPT (Institute of Technological Research of Sao Paulo State, Brazil).

Slight differences were introduced in the specifications concerned, both relating to the dimensions of each physical element and of the assembling system.

The testing methods for evaluation of both empty and filled packages were also revised, with the aim of allowing laboratory appraisal results as close as possible to the results of the packages actual performance along their normal distribution circuit. The basis for related standards were elaborated accordingly.

The entire report reflects the great care of the expert in training of the counterparts, providing them with the theoretical basis for understanding and discussion of the research and quality control work concerned, and providing them with a general view and his personal comments on the main international standards and testing methodology on transport packages for fruits, vegetables and marine products. Wood treatment and cost analysis were also dealt with by the expert.

The expert recommends actual execution of laboratory and field test programmes for transport packages evaluation. He also recommends the definition of standards for these packages, either at national or ASEAN (sub-regional) level.

Joint efforts of the different national sectors involved, could bring together Government authorities dealing with distribution of fresh produce and fishery products, representatives of producer and distribution organizations, co-operatives and private business, as well as authorities in the area of forest resources and technology.

UNIDO recommends submission of the expert's recommendations to the Government, for consideration in light [illegible]nal policies concerned.