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DRAFT REPORT [1]

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Contents

Preface

At the initiative of the [illegible] Division of UNIDO an Expert Working Group [illegible] in Vienna. The meeting [illegible].

Attending the meeting [illegible] from Austria, Czechoslovakia, Denmark, Federal Republic of Germany, [illegible], India, Kuwait, Lebanon, [illegible], USSR, [illegible] and the United States. Also repre- sented [illegible], the United [illegible], the International Asbestos [illegible] International Asbestos-Cement Review.

Fibre-cement [illegible] term is used [illegible], e.g., [illegible] cement pipes. [illegible] devel- oping [illegible] of cement. The [illegible] materials [illegible].

The [illegible] classifica- tion, [illegible] materials. [illegible] covering the various [illegible], the [illegible] pulp [illegible], wood-wool [illegible] and the [illegible] construction. [illegible] resources [illegible] manufacture [illegible] building [illegible].

The meeting [illegible] A. [illegible] Chittenden as vice-chairman. Mr. [illegible] Mr. J. A. [illegible] and Mr. S. A. [illegible], [illegible] Division of UNIDO, served as Director [illegible].

[illegible] conclusions and recommendations [illegible] of this report.

The report [illegible].

Part I Introduction [illegible] fibre-cement [illegible] by the [illegible] cement [illegible] countries.

The information presented in this section may help the reader to appreciate the importance of the subjects discussed at the meeting. In addition, some of the more general aspects of the asbestos cement process presented at the meeting are discussed.

Part II <u>General</u>. In this section an attempt is made to define the needs of developing countries in terms of the stages of their development. It was felt that this kind of thinking is essential particularly in the field of building materials in order to make assistance more meaningful to the recipient countries and thereby more effective.

Part III contains a summary of the meeting and the conclusions and recommendations adopted.

Summaries of the papers presented and a list of the participants, agenda and documents are found in the appendixes.

Part I

Introduction

Theory and definition of terminology

By fibro-cement composites [illegible] combination of a binder and a fibrous material. The binder can be an inorganic [illegible] material such as gypsum or portland cement or an organic resin such as starch or phenolic resins. The fibrous material [illegible] inorganic or organic in nature. If the volume of the binder phase is the predominant part of the composite material the binder phase is called the matrix in which the fibres are embedded.

Inorganic building materials are [illegible] strength. However, poor resistance against tensile and impact forces [illegible] the effective utilization of their [illegible] in structural applications. Inorganic fibres [illegible] properties [illegible] certain conditions [illegible] these materials valuable [illegible] in composites [illegible] that they exhibit no creep or plastic flow. [illegible] no [illegible].' Fracture occurs [illegible] always in [illegible] strength [illegible] weak matrix.

Asbestos fibres in [illegible] cement

The [illegible] fibre-cement composite material is asbestos cement in its various forms. [illegible] trying to [illegible] asbestos cement industry of their own [illegible] not only [illegible] with major capital expenditures for purchasing production equipment [illegible] difficult raw materials situation which applies as well to countries with already established asbestos cement industry.

Part of the problem is the fact that deposits of [illegible] of asbestos are limited to a few specific [illegible] Africa, Canada, USSR, Australia and USA. Consequently, [illegible] to cover their requirements through imports at the expense of foreign exchange.

In the last fifteen [illegible] world [illegible] consumption [illegible] than doubled. With the rising demand world prices are climbing. In the more or less distant future the prices of the higher grades of asbestos may be beyond the means of many poor countries. At present the total known deposits of all varieties of asbestos are estimated at about 150 million tons. If trends in asbestos consumption continue at present the known deposits may be exhausted by the turn of the century.

On the [illegible] for using asbestos [illegible] asbestos and for developing substitutes [illegible] more important.

Asbestos production
(Largest producers)

Thousand metric tons

Country	[illegible]	[illegible]	1967
[illegible] 1/	[illegible]	[illegible]	[illegible]
Australia..............	[illegible]	[illegible]	[illegible]
Brazil..............	[illegible]	[illegible]	337.[illegible]
Canada..............	[illegible]	1016.[illegible]	1417.3
China (mainland) 2/...	...	[illegible]0.0	150.0
Cyprus..............	[illegible]	[illegible]	[illegible]
Finland..............	10.[illegible]	[illegible]	[illegible]
India..............	0.7	1.[illegible]	7.0
Italy..............	[illegible]0.4	[illegible]	100.7
Japan..............	[illegible]	[illegible]	[illegible]
Rhodesia, Southern.	[illegible]	[illegible]	150.0 2/
South Africa 4/......	[illegible]	[illegible]	[illegible]
Swaziland..........	[illegible]7.3	[illegible]	[illegible].0 2/
USSR 2/..............	[illegible]0.0	[illegible]0.0	[illegible]0.0
United States 3/.....	[illegible]	[illegible]	111.[illegible]
Yugoslavia 4/.........	[illegible]	[illegible]	[illegible].0

Note. The figures [illegible] fibre and asbestos powder.

1/ Excluding [illegible], North Korea and [illegible].

2/ Source: [illegible].

3/ [illegible] producers.

4/ Excluding asbestos powder.

Source: U.N. Statistical Yearbook 1968

Part I

Introduction

Theory and [illegible]

By fibre-[illegible] fibrous [illegible] such as gypsum or portland [illegible] plastic [illegible]. If the volume [illegible] material [illegible] embedded.

Inorganic [illegible]. However, poor [illegible] the effective [illegible] applications. [illegible] certain [illegible] these [illegible] exhibit no [illegible]. Frac- ture occurs [illegible] always [illegible] strength [illegible] matrix.

Asbestos [illegible]

[illegible] in its various forms. [illegible] cement industry [illegible] capital expen- ditures [illegible] raw materials [illegible] already established [illegible].

Part of the [illegible] asbestos [illegible] Africa, Canada, USSR, Australia and USA. [illegible] over their requirements [illegible].

In the last fifteen [illegible] world [illegible] consumption [illegible] doubled. [illegible] lashin. In the [illegible] r [illegible] may be beyond [illegible] of all [illegible] tons. [illegible] trends in [illegible] exhausted [illegible]

[illegible] and for [illegible]

[illegible]

[illegible]

Country	[illegible]	[illegible]	[illegible]7
[illegible]	[illegible]	[illegible]	[illegible]
Au[illegible]........	[illegible]	[illegible]	[illegible]
[illegible]zil..............	[illegible]	[illegible]	[illegible]57.[illegible]
[illegible]..............	[illegible]	[illegible]	[illegible]17.[illegible]
[illegible]...	[illegible]	[illegible]	[illegible]0.0
Cy[illegible]............	[illegible]	[illegible]	[illegible]
Fi[illegible]...........	[illegible]	[illegible]	[illegible].1
[illegible]..............	[illegible].7	[illegible]	7.0
[illegible]...............	[illegible]	[illegible]	[illegible]00.7
J[illegible].............	[illegible]	[illegible]	[illegible]
R[illegible], [illegible].	[illegible]	[illegible]	[illegible]0.0
S[illegible]......	[illegible]	[illegible]	[illegible]
Sw[illegible].........	7.[illegible]	[illegible]	[illegible].0
USSR.............	[illegible]	[illegible]	[illegible]0.0
[illegible].....	[illegible]	[illegible]	[illegible]
Y[illegible]........	[illegible]	[illegible]	[illegible].0

[illegible] and asbestos powder.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] Statistical Yearbook 1968

The term asbestos is applied [illegible] fibrous [illegible] minerals [illegible] Mineralogically, [illegible] classification. [illegible] Chrysotile, [illegible] formed [illegible] Serpentine. [illegible] properties [illegible] Chrysotile asbestos [illegible], [illegible] (C[illegible]) on the [illegible] [illegible] the [illegible] grade. These properties [illegible] type of [illegible] fibres. [illegible] 93% of the total world production.

The [illegible] 7. [illegible] asbestos is [illegible] Chrysotile. [illegible] Crocidolite [illegible] known as [illegible] asbestos. [illegible] Crocidolite account for [illegible] of the total world production. [illegible] [illegible] than with Chrysotile, [illegible] lower [illegible] tensile strength. Due to the [illegible] [illegible] [illegible] the absorp- tive properties on the surface of the [illegible] well devel- oped [illegible] with Chrysotile. [illegible] resistance of these [illegible] Therefore, [illegible] in the manufacture [illegible] conditions.

The [illegible] world production [illegible] types of asbestos [illegible] [illegible] of the [illegible] presently available by which [illegible] to a larger extent.

Standard Asbestos Cement [illegible]

[illegible] the most wide spread use, [illegible] point of our discussion. This [illegible] introduction into the manufacturing process of asbestos cement [illegible]. New infor- mation [illegible] is also included.

In the manufacture of asbestos cement the two basic raw materials –

asbestos and cement - are slurried in water and transferred to a filtering device where the water is removed. The de-watered sheet is then compressed to remove additional water. After this operation the product is stored for 24 - 48 hours for setting of the cement. Final strength is developed after a further storage for 1 - 2 months. Some manufacturers apply curing at elevated temperatures in order to reduce the length of storage time. From the above comments it is obvious that the way in which asbestos fibres are felted in the presence of cement and the ease with which the excess water can be removed is of great importance for the process and for the properties of the final product.

Cement

The specifications for cement used in the asbestos cement process have to satisfy both the properties of the finished product and the requirements of the manufacturing process. In order to maintain a high speed of filtration and satisfactory production rate on the machine it is essential to avoid the formation of colloidal particles which reduces the filtration rate. The setting of the cement should be delayed until filtration and molding are completed. In order to meet these requirements the cement should be high in Tricalcium Silicate (C_3S) and low in Tricalcium Aluminate (C_3A). The cement should also be of reasonable fineness and the klinker should preferably be processed by closed circuit grinding. Care must be taken that the gypsum added is in the form of dihydrate rather than the hemihydrate.

According to USSR standards portland cement for use in asbestos cement manufacture should meet the following specifications:

free CaO	max. 1%
MgO	max. 5%
C_3S	min. 50%
C_3A	max. 8%
SO_3	1,5 - 3,5
initial set	1 hr. 30 min.
final set	12 hrs. max.
Fineness:	fraction larger than 70 microns - 7%

Asbestos

In asbestos cement manufacture the fibre component plays a triple role.

1) It interconnects the cement grains forming [illegible] and matrix.

2) It forms a filter matrix [illegible] proper draining properties [illegible]. For a given cement (1) and (2) are largely a function of the texture and the specific surface of the asbestos fibres.

3) It must maintain its strength when exposed to the alkaline conditions of cement paste and to the subsequent curing process.

Mechanical strength of asbestos cement products depends to a large extent on the ratio l/d where l is the length of the fibre and d the diameter of the fibre bundle. This means that when shorter fibres are used additional shredding is required in order to reduce d if the same strength is to be maintained.

Another important parameter is the asbestos/cement ratio which to a great extent depends on quality and type of the asbestos used. The optimum ratio has to be determined in each individual case. Up to a certain ratio strength of asbestos-cement products increases with increasing content of fibres. Beyond this point, additional asbestos not only leads to increased cost but also to lower bulk density and increased water absorption. Normally, from [illegible] to [illegible] parts by weight are used for 100 parts of cement depending on raw materials and the type of product one wishes to manufacture.

Part II

General

Quality and Standards

One of the important aspects of the meeting has been that experts from both developing nations and from the industrialized parts of the world were assembled. A number of interesting discussions were focused on trying to define the true needs of the developing countries and the type and quality of building materials they require.

Under certain simplifying assumptions we can distinguish mainly three stage of development.

Stage a). In this stage will small industries prevail. The types of material required are rather unsophisticated and can be manufactured with a minimum of technical equipment and know-how. A number of publications [illegible] industries is available.

Stage b). Development of small scale industry becomes necessary. At this stage [illegible] developed countries is either not available or [illegible] from these countries has to be modified [illegible] relevant to the needs of the recipient country. [illegible] rather light working [illegible] a limited degree of sophistication. It is at this stage where the assistance of UNIDO [illegible] and where the greatest contribution [illegible] towards improving living conditions in a larger number of countries.

Stage c). Development of larger industries where technology from developed countries can be applied without major modification and where it is only necessary to consider economic conditions and local customs. At this stage UNIDO's advice will [illegible] of the evaluation [illegible] feasibility and pilot studies, assistance in finding proper financing, etc. However, commercial interests will be available for supplying technology, plant construction, start-up and [illegible] operation of the production facility.

A great number of developing countries has to be placed in group b) [illegible] availability of certain raw materials [illegible] country in a higher group in certain specific areas.

Given [illegible] of products which should be made available [illegible] of development given in this classification. In countries [illegible] group b) products mentioned as substitutes for cement [illegible] will initially be of greatest interest.

At a later stage [illegible] cement products with or without the addition of [illegible] could be introduced.

[illegible] building materials which could be produced and marketed in developing countries [illegible] extent on the stage of development, the quality level required must be seen in terms of the final [illegible] products. [illegible] functional terms is [illegible] ability [illegible] given life [illegible] materials. [illegible] newer [illegible] tion [illegible] be [illegible] or increase [illegible] standard [illegible] ditions. [illegible] of building materials [illegible] by function [illegible] a very essential property. [illegible] of building materials [illegible] placed [illegible] ability towards [illegible] materials [illegible] factors.

Even in the [illegible] countries [illegible] functional approach to quality [illegible] difficult. [illegible] that this type of [illegible] run, standard [illegible] the needs of the customer. [illegible] do their own thinking [illegible].

It [illegible] requirements [illegible] used locally [illegible] in standard [illegible] in performance. [illegible] materials market in [illegible] countries [illegible] supply.

The [illegible] test methods used [illegible] evaluation process. [illegible] standards can lead [illegible] materials or which [illegible].

Statistical Information

In [illegible] countries [illegible] the field of construction materials [illegible] statistical information [illegible] already established. Attention [illegible] future needs in terms of housing production required.

Part III

Summary

Among the various [illegible] artificial fibre-cement products [illegible] important part. Asbestos cement materials which [illegible] the form of flat sheets, siding, ducts and pipes [illegible] Portland cement reinforced with asbestos fibres.

A number of production processes are available for manufacture of the [illegible] types of asbestos cement products. For the production of flat [illegible] considered to be the most [illegible] product choice. [illegible] process is known for simplicity [illegible] fibres if desired. A dry moulding process [illegible] developments in this field which may [illegible] opportunities in the future in terms of smaller and more versatile plants for markets of limited size.

The raw material requirements have been discussed in greater detail. Good grades of asbestos fibres are in short supply, command high prices and deposits are restricted to a few specific areas. Most developing countries have to cover their [illegible] requirements through imports. Lower grades of asbestos are [illegible] generally available, also in some developing countries. Their application in asbestos cement products has been very limited [illegible] have been considered useless due to their [illegible] shortness of the fibres.

The working performance of low grades of Chrysotile and Amphibole asbestos has led to the development of chemical and physical methods by which the fibre bundles of [illegible] can be opened without fibre damage. Certain modifications of the asbestos cement process and additional processing of the [illegible] to permit partial substitution of high grade Chrysotile asbestos by lower grade fibres.

The other possibility pursued in this [illegible] hopefully the full replacement of asbestos fibre with artificial fibres. Attention has been focused in particular on inorganic fibrous materials of vitreous nature such as glass and mineral wool. It is now well recognized that most glass and mineral fibres presently known are not stable in the alkaline medium supplied by the hydration reaction of portland cement.

The way in which this corrosion takes place is not entirely clear. It is suspected [illegible] stress corrosion. We must realize [illegible] fibres is not [illegible] and se[illegible] completely different types of materials which [illegible] from what we [illegible] present. So far, it has been possible to replace 10 - 0[illegible] so-called A-type [illegible] glass fibre at [illegible] sacrifice in strength and other performance properties in the finished product. This work is presently carried out on a semi-product scale. It is hoped that these fibres can be generally recommended as a partial substitute for asbestos in the not too distant future.

The use of vegetable fibres, [illegible] of cellulose nature has also been proposed [illegible] substitute for asbestos fibre, we must recognise that certain [illegible] frost resistance [illegible] water absorption [illegible] surface protection or treatment with, e.g., plastics [illegible] with severe climatic conditions. [illegible] this type of material may be completely satisfactory.

The [illegible] replacement [illegible] with vegetable fibres such as bamboo and other [illegible] available in many developing countries will lead to products which are [illegible] different from standard asbestos products. Therefore [illegible] on their own merits and it would be [illegible] by traditional standards established for asbestos cement products.

Saving in portland cement is possible by substitution of part of the portland cement with ground sand or inert fillers. Using the standard asbestos cement process this will lower strength [illegible] the amount of sand present. In certain [illegible] applications [illegible] drop in strength can be tolerated. In such cases, this kind of saving in raw material expenses is justified.

An autoclave process has been described in which about 40% of the portland cement can be replaced by finely ground sand. After curing at elevated temperature and pressure the matrix consists of calcium silicate hydrates of low basicity. Apart from [illegible] increase in [illegible] strength mechanical properties [illegible] deviate [illegible] from standard asbestos cement products. The volume of activity is greatly improved.

In light of the difficulties which developing countries experience in obtaining raw materials for asbestos cement products it was obvious to look for possibilities by which asbestos cement can be replaced by other materials. Consequently, the idea has been voiced that it might be preferable to design completely new products rather than finding substitute raw materials for the existing asbestos cement process. In this connexion, we are particularly grateful to the authors who have provided us with the theoretical aspects of fibre reinforcement in cementitious materials. These thoughts may provoke research work in this field which in turn may open the way for many interesting developments in the future. At this meeting a process has been mentioned by which gypsum plaster reinforced with 5 - 10% glass fibre can be produced for a number of major applications. In countries without a local cement industry or with gypsum deposits this may be an acceptable alternative for many applications where otherwise asbestos cement or wood is applied. Another process with suitable fibres from jute, paper or paper and other types of waste fibres can be wet felted in combination with mineral binders and fillers. These sheets are afterwards impregnated with asphalt. Roofing sheets of good durability have been obtained by this process. This process is successfully applied in a number of industrialized and developing countries. The traditional wood-wool slab process using locally available timber may also in many cases provide an answer to the immediate needs of the building materials market. In this area development work may ultimately provide not only small scale plants but also a wider selection of locally available raw materials than we presently have at our disposal.

The various types of dry and wet felted mineral wool products are essentially different from asbestos cement and related materials in both properties and application. The low density products are useful for thermal insulation in homes and industrial installations while higher density materials find application in acoustic and high temperature insulation. Mineral wool boards surfaced or impregnated with asphalt are used as insulating roof decks.

A number of processes of great versatility are available for developing countries which have the necessary raw materials in the form of either natural stones of proper chemical composition or slag from metallurgical melting operations. In most cases a cupola in combination with a centrifugal spinner is recommended. The binders used in low density insulation are mostly phenolic resins. Wet felted mineral wool products carry clay and starch type binders.

As plastic materials become available in the developing countries in sufficient quantities and at reasonable prices their use in building may become an economic proposition. A process has been described by which sand and other waste materials can be combined with unsaturated polyester resin into building units. Several types of plastic materials can be used to decorate the otherwise poor surface characteristics of asbestos cement products. The thermal insulation properties of asbestos cement can be improved by combination with either mineral wool or rigid plastic foams in the form of various types of sandwich constructions.

In the more or less distant future specially treated glass fibres may become available for use as reinforcement of cements. Research and testing work in this field is in progress.

Among the more general aspects, the meeting also discussed the ways by which developing countries can set reasonable standards for quality, sizes and raw materials related to asbestos cement and similar products.

Several participants indicated that a number of countries may be willing to share their technical know-how if approached through the proper channels. Mr. Laptrikov suggested that advances in process technology in the USSR may be of particular interest. Experience in India on the use of cellulose fibre could be of value to other countries. Mr. Aulieri mentioned successful low cost housing schemes from Kuwait.

Conclusions

1. In the conventional asbestos cement process, the partial replacement of high grade asbestos with lower grades particularly of the Amphibole type is possible without serious deterioration in performance properties by changes in certain process parameters or by additional pressing of the moulded sheets.
2. Low grade Amphiboles require a special treatment by which the fibre bundles can be opened without disintegration. A carbon dioxide treatment or a treatment with surfactants has been proposed.
3. For the processing of low grades of Chrysotile equipment is available which opens the fibre bundles without mechanical damage to the individual fibre.

4. The degree of replacement depends on the type of asbestos available and on how much decrease in physical properties can be tolerated in the finished product. This in turn is a function of the application for which the product is designed. The [illegible] asbestos in the production of pressure pipes is not recommended.

5. Semi-production runs have indicated that 10 - 20% of the asbestos content can be substituted [illegible] the so-called A-type mineral fibre without decrease in strength properties.

6. Substitution of asbestos with cellulose pulp fibres has been practiced in a number of countries. In cases where lower bending strength and higher water absorption is of no importance, this possibility should be considered. Under severe climatic conditions protection of these materials by surface coatings or by impregnation is indicated.

7. The complete replacement of asbestos by pulped or unpulped vegetable fibres such as [illegible], etc., leads to building materials which have properties that deviate from those of standard asbestos cement products at a number of points. Their suitability and useful service life will depend on climatic conditions. An evaluation in these terms will be required for each country or region.

8. About 40% of the portland cement in asbestos cement products can be replaced by finely ground silica sand in combination with an autoclave treatment performed at elevated temperatures and pressure. A slight decrease in impact strength but improved volume stability is obtained.

9. Ground silica sand or inert fillers can replace a portion of the portland cement in asbestos cement products without subsequent autoclave curing. However, this method is restricted to products where strength is not an essential factor.

10. It has been mentioned that profiles and other design features concerning the geometry of sheet products can be optimized with regard to load bearing capacity. Thereby, it has been possible to reduce the thickness of the sheets by 10%. The savings experienced apply to all raw materials, i.e., both cement and asbestos.

11. Due to its versatility the Hatschek machine is considered to be the most applicable equipment on over-all performance. In addition to the standard processing equipment an extrusion process and a dry moulding process are now available. The applicability of these new processes in developing countries requires further evaluation before definite recommendations can be made.

12. Completely new products have been [illegible] for the replacement of asbestos cement products. [illegible] fibre [illegible] are applied [illegible] sheets.

13. C[illegible]ments pr[illegible] – 10 [illegible] glass fibres [illegible] and [illegible].

14. The conventional [illegible] to be of interest for countries [illegible] in pr[illegible] and assure it [illegible].

15. The various aspects of production [illegible] in general have been presented. [illegible] developing countries [illegible] natural stone or industrial [illegible] products [illegible] used for thermal and acoustic [illegible] industrial installations.

16. In the future specially treated glass fibres [illegible] reinforcement may become available.

17. A newly developed process has been presented by which building materials can be produced from [illegible], industrial and agricultural [illegible] with unsaturated polyester resins as binder. It is claimed that this process can be carried out in small scale units and [illegible] skilled labour.

18. Further developments in the plastics industry and its establishment in the developing countries may eventually make the use of [illegible] materials attractive for use as binders for mineral and glass fibres, for surface coatings and for rigid insulating [illegible].

Recommendations

1. Technical assistance and advice [illegible] all stages of the establishment and operation of asbestos cement plants should be made readily available to developing countries.

2. Data sheets on the asbestos cement process and on asbestos cement products should be prepared in order to provide a general background for selecting the economically most suitable plant size and type for a given country. In cases of limited markets, subregional and regional co-operation should be encouraged.

3. The repl[illegible] of [illegible] asbestos by [illegible] lower and less expensive [illegible] should be encouraged. In support[illegible]

a) [illegible] types of [illegible] process;

b) [illegible] satisfactory [illegible] modifications have been developed.

[illegible] existing [illegible] asbestos [illegible]

4. [illegible] of new [illegible] through [illegible] with the support [illegible].

5. [illegible] fibres [illegible] in many [illegible] industrial and agricultural [illegible]. In [illegible] just existing [illegible] fibres. Efforts [illegible] fibres in [illegible] materials. [illegible] with FAO.

6. [illegible] reinf[illegible] asbestos [illegible] beneficial to [illegible]. A pilot plant [illegible] this [illegible] country. Further studies of [illegible] useful.

7. [illegible] UNIDO [illegible]s, production [illegible] wool, [illegible] vegetable fibres [illegible] developing countries [illegible] possibilities [illegible] materials. Therefore, the [illegible] assessment [illegible] situation, the various aspects of financing and the

suitability of the building materials in the given country.

8. From the equipment angle special emphasis should be laid on the design of the plants [illegible] without excessive sophistication. Pilot projects in this area particularly of cellulose type fibres should be established by organizations [illegible] system.

9. UNIDO in co-operation with other national and international agencies engaged in the field [illegible] the technical know-how available for the [illegible] materials [illegible] in this meeting. Of particular interest [illegible] in the field of low cost housing. [illegible] industrialized [illegible] construction [illegible] materials [illegible] file.

10. It must be [illegible] materials required in developing countries [illegible] the stage of development [illegible] realistic quality specifications [illegible] which are based on the functional [illegible] from [illegible]. [illegible] use of [illegible].

11. UNIDO [illegible] cement [illegible] products. [illegible] improve productivity.

12. The use of thermal [illegible] climates wherever [illegible] living conditions. [illegible] consumption may in many [illegible] important [illegible].

13. The production of [illegible] insulation products [illegible]. Countries with [illegible] established glass industry [illegible] glass fibre manufacture if capital and [illegible] for such a project.

14. UNIDO should promote [illegible] the development of completely new fibrous [illegible] inorganic building materials for the replacement of [illegible] cement products for roofing, cladding, insulation and wall materials.

Summaries of Papers Presented

K. Thiele: Some Aspects of the Choice of Asbestos Cement Machinery

Asbestos cement products are manufactured mainly in the form of sheets or as pipes. The paper surveys the kinds of processes available for the manufacture of these products. Recommendations are made concerning type of process equipment and plant size which is most suitable for developing countries.

Hatschek Machine. This type of equipment is common for the production of flat and corrugated sheeting material. The asbestos cement sheet is formed on a sieve cylinder under application of vacuum. The great popularity of the Hatschek process is based on its extreme versatility with regard to product choice. The fact that a moderate size one vat plant with an output of 30 - 40 tons per day can be expanded gradually into a sophisticated 3 vat plant producing 150 tons of asbestos cement products per day makes this process a natural choice for many countries where asbestos cement products have not been produced before. The disadvantage of the Hatschek Machine is its limitation to asbestos as the fibrous component. However, from the standpoint of the overall performance it is believed that the Hatschek process in many countries will be the dominating method for producing asbestos cement products.

During the discussion it was mentioned that in recent years a number of improvements in this kind of equipment were made in the USSR. More powerful multistage presses permit the production of high strength material.

Magnani Sheet Machine. In this type of equipment the asbestos cement slurry is distributed by means of a distribution pipe on an endless band moving in a reciprocating way so that the ultimate thickness is built up gradually. Then the sheets are pressed between cylinder rolls, cut and transferred to the curing chamber. The process is remarkable for its simplicity and good running features. It is also suitable for non-asbestos fibres. Contrary to the Hatschek machine the fibres are not oriented. Consequently, the strength of the products manufactured on this equipment is somewhat lower. Besides, the sheets are generally not very suitable for hand moulding.

Some data concerning these two processes is accumulated in Tab. 1 which may be used for a first-hand orientation about cost and capacity of asbestos cement machinery.

Other Processes. Johns-Manville (USA) has developed an extrusion process which may [illegible] prominence for certain types of products. Another process developed by the same firm applies a dry mixing technique followed by wetting with the amount of water required for the hydration of cement. The surface finishing is applied by vibrating with pressing rollers. The strength of the materials produced in this process is [illegible] than the one obtained in [illegible] felting machines. The most important feature of this method lies in the [illegible] to incorporate – at least in principle – any type of fibres. The extremely low [illegible] of [illegible] is another factor of importance in dry climates.

Manufacture of asbestos cement pipes on the Magnani Machine. The pipes are formed by depositing an asbestos cement layer from a slurry on a canvas clad hollow steel mandrel under suction. The outer profile is formed by rotating rollers. The steel mandrel with the formed pipe is then transferred to the [illegible]. The pipes are precured for a period of 10 hours. The final curing takes from 3 to 7 days.

An aggregate for manufacture of [illegible] pipes can be added to existing asbestos cement plants at [illegible] cost. In developing countries it is recommended to restrict pipe production to begin with to either ducts or low pressure pipes. The manufacture of high pressure pipes requires a high degree of sophistication and experience. Also, plant costs are in the magnitude of US$ [illegible] million of which [illegible] is due to mechanical and electrical equipment the maintenance of which, in many cases, [illegible] beyond the capabilities of locally available [illegible].

Tab. 1. Asbestos Cement Plants – Capacity and Cost

	Capacity tons/24 Hrs.	Investment excl. building, site and freight	Power Consumption KW/24 Hrs.
a) Production of sheets			
Hatschek Machine			
1 vat machine	30–40	[illegible].000 US$	[illegible]0
3 vat machine	[illegible]	[illegible].[illegible]00.000 US$	
Magnani Machine	160	[illegible]00.000 US$	[illegible]75
b) Pipe plant			
Magnani Method			
3 meter aggregate	9	[illegible].000 US$*	
4 meter aggregate	12		

* for installation in already existing plant.

V. Lap[illegible]: [illegible] Production of Sheets [illegible] Pipes in the USSR

USSR scientists [illegible] 40[illegible] the portland cement [illegible] nd. A [illegible] grinding of portland cement [illegible] SiO_2 min.) was found [illegible] suitable [illegible] processing. After [illegible], the asbestos cement products [illegible] autoclave [illegible] according to [illegible] pressure [illegible] t. (175 C) and curing time at full pressure [illegible]. [illegible] that finely ground silica is [illegible] even if during the hydration of portland cement [illegible] silicates of low basicity which [illegible] excellent [illegible] the surface of the asbestos fibres. Economically, this [illegible] reduction in the amount of portland cement with corresponding [illegible] costs. In addition, the curing time for asbestos cement products [illegible] reduced from 1 - 2 weeks to [illegible] - 3 days.

Apart from [illegible] strength the properties of autoclave cured asbestos cement products are equal or better than those made by the standard process. In particular, [illegible] greatly improved volume stability [illegible] resistance of autoclave cured products.

During the [illegible] that in times of [illegible] used to replace part of the portland cement. However, without autoclave curing [illegible] strength [illegible] performance [illegible] experience.

The [illegible] important [illegible] optimizing the shape, [illegible] the geometry of asbestos cement [illegible] strength [illegible] carrying capacity. The results have shown that thickness can be reduced by as much as 10% without decrease in the overall strength. Thereby, corresponding savings in raw materials [illegible] obtained.

H. Schultheis: Complete [illegible] Substitution of Asbestos Cement by Plastic Materials

Asbestos cement [illegible] structure [illegible] insulation [illegible] r.

A number of [illegible] is [illegible] asbestos cement sheets can be covered [illegible], Polyurethane [illegible] Epoxy [illegible] tings. The first two are the most [illegible] the Epoxies despite their excellent properties [illegible] (T[illegible]).

The [illegible] insulati[illegible] [illegible] by sandwich [illegible] with [illegible] a variety of [illegible], [illegible], [illegible], the other [illegible]. The [illegible] used in [illegible] from which [illegible] the form [illegible] [illegible]. [illegible] [illegible] raw material [illegible].

[illegible]

	[illegible]
Polyester Resins	-,[illegible]
Polyurethane Resin	-,7[illegible]
Epoxy Resin	[illegible],[illegible]0

A.J. Majumdar: [illegible] Glass Fibre Reinforcement [illegible]

The [illegible] generally [illegible] entirely clear. It is [illegible] for the [illegible] strength [illegible]. So far it has [illegible] in the [illegible] medium provid[illegible] [illegible].

By [illegible] fibre reinforcement has been successfully [illegible]. A [illegible] spray of plaster slurry [illegible] fibre [illegible] is distributed over the surface of [illegible] mould. The [illegible] required to make the binder slurry spread [illegible] by application of vacuum or pressure. Thereby, the [illegible] to give [illegible] matrix [illegible] strength. The glass fibre [illegible] the spray [illegible] distribution of the fibre in the [illegible] matrix. [illegible] difficulties which [illegible] experienced [illegible] larger quantities of [illegible] fibres. [illegible] up to [illegible] by weight of glass fibre have been prepared.

The physical properties of glass fibre reinforced gypsum composites are summarised in Table 3. In practical application a particular advantage of these composites is the fact that a failure under loading occurs gradually rather than suddenly. The material shows plastic stress-strain behaviour during loading or cutting which does not affect the properties much. Impact strength is about ten times while Young's modulus is about 50% higher. The fire resistance of glass fibre reinforced gypsum is superior to ordinary plaster board.

Glass fibre reinforced gypsum composites can be used for the manufacture of panels, floor and ceiling units. Strength and durability tests indicate that these panels are suitable for use in buildings up to two storeys high. The manufacturing process is simple and the investment sufficiently low to be adapted to small industries.

In most developing countries glass fibre rovings will have to be imported. However, plaster of Paris can be produced locally in many countries at relatively low investment or prepared with cement plants. The possible use of vegetable fibres in combination with gypsum is also mentioned.

Table 3.

Mechanical Strength Properties of Glass Fibre Reinforced Gypsum with 0 and 7 weight % of Fibre

	Plaster of Paris		α - Hemi-hydrates	
% fibre	0	7	0	7
Modulus of Rupture (kg/cm²)	75 (?)	263 (?)	133	352
Tensile Strength (kg/cm²)	42 (?)	127	56	155
Impact Strength kgcm/cm²	1	30	3	30
Compressive Strength kg/cm²	320	260 (?)	550	420
Density kg/m³	1500	1600 (?)	1300	1950

S.A. Klink: <u>Fyrecrete - Glass Fibre Reinforced Plastics to strengthen Concrete Structures</u>

A glass fibre reinforced concrete has been introduced under the name Fyrecrete. The specially treated glass fibre used in this product are called Fyrerites.

In the experiments reported, E-glass fibres have been used. Fibres in the form of rovings are impregnated with a thermosetting resin in order to protect the fibres from attack by the alkaline components in portland cement. Besides, the resin impregnation ensures an even transfer of the stresses to the individual fibres in the filament. It was found that an impregnation of the fibres with a two component Epoxy resin fulfills the dual purpose of fibre protection and stress distribution. After curing the impregnated fibres are chopped to suitable length. The cost of Fybrites is reported to be in the magnitude of US$2.20 per kg.

When mixing the impregnated fibres with the concrete mix it is important to strike a correct balance between the various mix components and the types of Fybrite [illegible]. Strength properties of the concrete increase with increasing concentration of the Fybrites in the mass. In particular, the increase in tensile strength is very pronounced. Therefore, this type of glass fibre reinforced concrete is believed to be applicable in most constructions where steel reinforcement is presently used. Still being very new, this material will require additional testing before all its properties are explored. Of particular importance will be the long-term performance in actual construction and the experience arising from field tests.

R. Singh: Fibrous and Raw Materials Produced from Industrial Wastes

Part I. Use of Low Grade Asbestos in the Manufacture of Asbestos Cement Products

The general shortage of high quality of Chrysotile asbestos and its rising prices on the world market have made it imperative for many countries to develop low grade asbestos which for a long time have been considered waste materials.

One main difficulty in developing low grade asbestos deposits is the lack of grading standards in particular for certain Amphiboles. The paper describes attempts to classify these deposits of asbestos according to their properties in order to distinguish between useful types and those qualities which are unsuited for the manufacture of asbestos cement products. A number of tests have been devised to determine the physical and chemical properties of asbestos, e.g., tensile strength and the adsorption of lime from cement paste to mention two of the most important properties. In case of low grade Amphibole these characteristics vary a great deal even within the same deposit. It is recognized that the adsorptive properties of Amphibole asbestos are much lower than those of Chrysotile. The surface forces of Amphibolites are much weaker and the lime adsorbed from cement is largely held by physical adsorption without developing chemical bonds as Chrysotile does. Additional tests have been designed for determining:

a) degree of fibrization - either by means of a wet volume test or by determination of the specific surface by an air permeability method;

b) chemical composition (ratio between basic and acidic oxides);

c) alkali and acid resistance;

d) high temperature stability.

Although a lot can be learned from these test data about the nature of the asbestos it has not been possible so far to write clear specifications for Amphibolites with regard to their suitability in the asbestos cement industry.

A number of different methods of processing is reported by which it is possible to substitute part of the Chrysotile asbestos with low grade Amphibolites. An opening of the fibre bundles after treatment with surfactant solutions and application of high pressure (70 kg/cm²) to the sheets after forming leads many times to suitable products even if 80 - 90% of Chrysotile is replaced by Amphibolite. An opening of the fibre by means of conventional methods of shredding or crushing is generally not possible without grinding the material to dust. Another way of processing low grade asbestos is reported to be curing in moist CO_2 atmosphere for 28 days. In many cases suitable blends between Chrysotile and Amphibole produce good results. In particular, fibres of the Crocidolite group have excellent wet felting properties because of the porous nature of this asbestos.

Cost savings are reported to be up to 40% where local deposits of Amphibole are available. However, in many cases substitutions can only be applied for products where high strength is not a must.

The most interesting and sound method from a technical standpoint is a sandwich method where the central layer of the asbestos cement sheet is made of low grade asbestos while the outer layers which are exposed to compression and tensile forces are produced from higher grade fibre (neutral axis method). However, frequently the savings experienced by the use of lower grades of asbestos in the center of the sheet is compensated by the need for higher grades for the surface layers.

Part II. Bamboo Pulp Cement Building Boards

Extensive work has been done in India on using readily available bamboo as a fibrous raw material for inexpensive building boards which can be used to serve the low cost housing market.

In this process bamboo chips are pulped after 5 hours treatment under steam pressure with a 20% sodium hydroxide solution. Pulp and cement are mixed and the slurry processed in asbestos cement machinery. A pulp content between 7,5 - 10% was found suitable in many applications. The remaining 90 - 92,5% was rapid curing portland cement. In addition to normal asbestos cement machinery a hydraulic press is required capable of exerting a pressure of 25 kg/cm^2.

Flat sheets and roofing material produced by this process are now undergoing field trials in order to evaluate long term stability and other performance characteristics. Laboratory tests indicate that this material should be of great potential use in replacing asbestos cement for low cost housing. Samples of materials have been demonstrated.

Part III. Corrugated Asphaltic Roofing Sheets

Intensive work, particularly in Latin America and India, has led to the development of wet felted boards made with a variety of waste fibres largely of vegetable nature.

The boards are based on paper scraps, bagasse, jute waste, coconut fibre, rags, saw dust, straw, waste lumber, bamboo chips, cotton and wool rags or suitable combinations of these materials.

The selection of fibre raw materials is of great importance for the boards. Use of cotton and wool has a tendency to soften the boards and to increase porosity while jute produces harder and denser products. Clay is added as a filler and for obtaining a denser board.

The subsequent impregnation of the boards is carried out with a standard grade paving asphalt. The surfacing material can be made up of mineral granules, aluminium foil or aluminium paint. Plastic paint can also be used. The most economic surfacing is aluminium paint although foil gives the highest heat reflexion and best durability.

Process. The fibrous raw materials are soaked in water and are pulped in a hammer mill. Additional equipment is needed for removal of contaminations and for homogenizing the pulp before it reaches the forming machine. From there the felts are transferred to pallets for drying either in air or in an oven. After trimming the sheets pass a corrugation unit. Then, the boards are impregnated in an asphalt bath and surfaced with a dip coat of aluminium paint.

The material can be used to replace asbestos cement sheets for roofing purposes in areas where maximum temperatures do not exceed 45°C. Thermal insulation properties are reportedly good. Due to its greater toughness the material withstands transport over longer distances better than asbestos cement sheets. Production costs are reported to be approximately US$0,34 per m² (cost in India). Application economy is summarized in Tab 4. in comparison with other types of roof construction.

Tab 4.

Comparison of Various Types of Roofing - Cost and Properties (India)

Type Roofing	Approx Cost per m² $	Expected Service Life Years	Weight per 10 m²
Corrugated galvanized sheeting	12,50	30	55 up
Corrugated asbestos cement sheets	10,-	20	158
Single clay tiles on wooden battens	6,20	15-20	634 incl. batton
Corrugated asphalt roofing sheet	5,30	12-15	59

Some samples of these materials have been demonstrated.

A.E. Chittenden: <u>Proposed Research and Development Programme at the Tropical Products Institute on Wood-Wool Slab Manufacture in Developing Countries</u>

This paper places particular emphasis on how wood-wool slabs can be produced in developing countries using local raw materials to the largest possible extent. It shows how agricultural development can be tied together with industrial production of building materials in developing countries.

The basic raw materials of the process are timber and binders. In most cases portland cement is used as binder although experiments are under way at the Tropical Products Institute to develop other types of binders as an alternative for countries without a local cement industry.

For the time being, however, portland cement is the binder generally applied and this fact dictates the choice of timber which can be used. The process is based on the availability of cheap, fast growing timber of suitable quality. Work is now in progress to establish those types of wood which have suitable physical structure and chemical composition.

The process starts with the machining of timber into wood-wool. Particular emphasis is placed upon using the [illegible] of timber which cannot be used for other purposes. The wood [illegible] lignin fibre which also contains the [illegible]. [illegible] wool [illegible] into slabs under slight pressure. [illegible] - [illegible] the slabs are kept in [illegible] for [illegible] strength. The smallest units available for the manufacture of wood-wool [illegible] capacity of 300 tons. Plants for production of wood-wool slabs [illegible] in sizes from 2000 m^3 per year upwards. [illegible] plant sizes and simple equipment for small [illegible] manufacture of wood-wool [illegible] another phase of the work which is being [illegible] at the [illegible] Institute.

Chief application of wood-wool slabs is for [illegible], for partition walls and for ceilings. The [illegible] properties of wood-wool [illegible] make this material useful in the manufacture of [illegible] even for more expensive types of construction.

J. T[illegible]: S[illegible] Conditions of Asbestos Substitution in Asbestos Cement Products

After [illegible] for the standard asbestos cement process [illegible] interesting trial runs in which [illegible] fibre asbestos has been successfully [illegible]. An [illegible] of the filter produced [illegible] of the fibre [illegible] increase in strength. This effect is similar to the result obtained [illegible] asbestos fibres.

However, excessive use of short fibre [illegible] to products of lower strength and bulk density and higher water absorption. The degree to which [illegible] fibre asbestos with lower [illegible] can take [illegible] trials [illegible] the correct balance between [illegible] properties.

L[illegible] artificially [illegible] fibres [illegible] substitutes [illegible] asbestos. [illegible] this purpose [illegible] fibres, glass fibres, slag and basalt wool and Zirconia stabilized fibres [illegible] proposed. The results reported in literature have been contradictory. The inherent drawback of all these fibres is their much lower specific surface in comparison with asbestos and their poor stability in the alkaline medium prevailing in portland cement paste. Now for alkali stability [illegible] improved [illegible] the addition of Zirconia to the fibre is being investigated [illegible] manufacturers. Generally, no artificial fibre is known at the present time which has suitable long range stability in combination with portland cement.

According to the experiments carried out by the author, basalt wool with its [illegible] higher [illegible], greater stiffness and strength appears to be the most suitable substitute for the time being. But felting characteristics of this type of wool in combination with asbestos have been found to be very favourable. A replacement of 10 - 20% of the asbestos with basalt wool seems to be possible without loss in strength. These conclusions are based on [illegible] runs in production equipment.

L. [illegible]: [illegible] Substitution of Asbestos

The author reports the development of a so-called A-type mineral fibre which [illegible] substitute for 10 - 20% of the asbestos in asbestos cement [illegible]. Due to patent applications pending it has not been possible to include detailed information concerning the chemical composition of these fibres. It has been mentioned that the fibre can be produced by conventional mineral wool processes and raw materials. A few minor modifications have to be made in the production equipment in order to permit the addition of an additive to the melt the nature of which has not been disclosed. Some form of cleaning equipment has to be installed to separate the fibres from unfiberised particles. Presently, the price mentioned for this fibre is in the magnitude of US$200 - 250 per ton. The increased cost is caused by the additive mentioned and the cleaning of the fibre.

Further work is required if greater substitution of asbestos with mineral fibre is desirable. Under such conditions certain physical properties of the asbestos cement products will deteriorate with increasing degree of substitution. The surface of the product will then require protection by suitable coatings if the material is applied in colder climates.

I.A. Fremin: [illegible]
([illegible])

The author [illegible] technical [illegible].

The raw materials for [illegible] natural silica [illegible], [illegible], [illegible] gravel and others. [illegible] industrial waste products from [illegible].

It is [illegible] furnaces or electric furnaces [illegible] not available in granular form.

For fiberization [illegible] the most [illegible] performance. [illegible] jets with [illegible] fiberization. Occasionally, [illegible].

For dry felted products [illegible]. Urea-formaldehyde [illegible] low cost and because they [illegible] with relative [illegible] wool manufacturers themselves. [illegible] and, in [illegible], by [illegible]. [illegible] are bituminous [illegible]. Dry [illegible] densities below 160 kg/m^3.

Wet felted mineral wool products [illegible] certain types of paper making machinery such as [illegible], etc., and [illegible] binders. Their densities are [illegible] 400 kg/m^3.

Mineral wool products can [illegible] classified by their rigidity. [illegible] wool and stiched blankets [illegible] for [illegible] insulation in industrial installations. Flexible, semi-rigid [illegible] felts with or without [illegible] serve the home insulation market [illegible] in industrial application. Rigid block type insulation is frequently [illegible] temperature applications. Certain types of [illegible] felts [illegible] for acoustic insulations. Roof decks have been [illegible] felts with asphalt.

The paper contains [illegible] statistical [illegible] concerning the subject. Details about the practical application of mineral wool for home and industrial insulation are [illegible] ...

K.A. [illegible]ikter: [illegible] building materials, their Production and Application

This group of building [illegible] waste products in [illegible], [illegible] polymers as binders. The material [illegible] reinforcement by [illegible] fibres.

The [illegible]-line [illegible] developed [illegible] principally from the technology applied in the manufacture of steam cured calcium silicate products. The process is [illegible] where [illegible] of lime but no portland cement is available.

In those [illegible] where [illegible] binders are applied unsaturated polyesters are recommended for best [illegible] economy. It is claimed that building materials [illegible] for [illegible], ceiling, blocks, pipes, etc., can be manufactured [illegible] machinery without the use of skilled labour. These materials [illegible] introduced under the name Polycon[illegible].

Samples of the different building materials made from Polycon[illegible] have been demonstrated.

Appendix I

AGENDA

Sunday, 19 October 1969: Arrival of participants - accommodations in hotels

Monday, 20 October 1969: Meeting [illegible]
UNIDO Headquarters, Felderhaus, Rathausplatz 2

Morning Session

10:00-12:30
Registration of participants
Distribution of documents
Opening Address
Election of officers
Adoption of [illegible]

Introductory Remarks

W. A. [illegible] — UNIDO STAFF

Afternoon Session

Conventional asbestos-cement products. Manufacture and Machinery.

14:45-16:00
Some Aspects on the Choice of Asbestos-Cement Machinery.

K. [illegible] — DENMARK

16:15-17:30
Automation [illegible] of Production of Sheets and Pipes in the USSR

V. L[illegible] — USSR

Tuesday, 21 October 1969: Morning Session

[illegible] plastics and glass fibres. [illegible]

09:30-11:00
[illegible] Asbestos Cement by [illegible]

H. [illegible] — FRG

11:15-12:30
Gl[illegible] Reinforcement of Inorganic Building Materials

A. [illegible] — INDIA

Afternoon Session

14:30-15:45
Fycrete-Glass Fibres Reinforced Plastics to Strengthen Concrete Structures

S. Klin[illegible] — [illegible]

Some aspects of manufacture and use of fibrous building materials in developing countries.

16:00-17:30
Fibrous [illegible] from Industrial [illegible]

R. Singh — INDIA

Wednesday, 22 October 1969:	**Morning Session**
09:30–11:00	Pr[illegible] and Development Programme at the [illegible] Institute in [illegible]-[illegible]l Slab [illegible] Developing Countries
	A. [illegible] — **UK**
	Substitution of [illegible] mineral fibres in [illegible]-[illegible] sheets. Mineral wool derivatives.
11:15–12:30	[illegible] Substitution in Asbestos-Cement Products
	J. [illegible] — **HUNGARY**
	Afternoon Session
14:30–15:45	[illegible] Substitution of Asbestos
	L. [illegible] — **CSSR**
16:00–17.30	[illegible] and its Products. Production and Use. [illegible] (USSR)
	N. [illegible] — **USSR**
Thursday, 23 October 1969:	**Morning Session**
	[illegible] of [illegible] and cement-polysand [illegible].
09:30–11:00	[illegible] Materials, Their Production and Application
	K. [illegible] — **AUSTRIA**
11:15–12:30	General discussion on [illegible], specific problems arising from discussions, adoption of proposals for the preparation of the Expert Group Report, report of the Rapporteur, etc.
	Rapporteur: **G. [illegible]** — **AUSTRIA**
	Afternoon Session
14:30–17:30	Plant visit
Friday, 24 October 1969:	**Morning Session**
09:30–13:00	Preparation of conclusions and recommendations for the report Adoption of recommendations Closing of the meeting

Annex II

[illegible]

Experts

Mr. Berger, Otto	Head of Research and Development Laboratory [illegible] Industri A/S Lund[illegible] [illegible] Denmark
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Appendix III

Symbol	Title
ID/WG.44/1	PROVISIONAL AGENDA
ID/WG.44/2 ID/WG.44/2 Summary	GLASS FIBRE REINFORCEMENT OF INORGANIC MATERIALS - Dr. A.J. Majumdar (Senior Principle Scientific Officer, Ministry of Public Building and Works, Building Research Station, Garston, Watford WD2 7JR, United Kingdom)
ID/WG.44/3 ID/WG.44/3 Summary	PROPOSED RESEARCH AND DEVELOPMENT PROGRAMME AT THE TROPICAL PRODUCTS INSTITUTE IN WOOD-WOOL SLAB MANUFACTURE IN DEVELOPING COUNTRIES - Mr. A.E. Chittenden (Chief Experimental Officer, Tropical Products Institute, Ministry of Overseas Development, Culham, Abingdon, Berkshire, United Kingdom)
ID/WG.44/4 ID/WG.44/4 Summary	SOME CONDITIONS OF ASBESTOS SUBSTITUTION IN ASBESTOS-CEMENT PRODUCTS - Prof. Dr. J. Talabér (Director, Central Research and Design Institute of the Silicate Industry, Ministry of Building and Works, Budapest X, Bihari u. 5, Hungary)
ID/WG.44/5 ID/WG.44/5 Summary	AUTOCLAVE METHOD OF PRODUCTION OF ASBESTOS CEMENT SHEETS AND PIPES IN THE USSR - Mr. V. I. [illegible] (Deputy Chief, Main Directorate of the Asbestos Cement Industry, Ministry of Building Materials Industries, 2/3, The Square of Nogin, Moscow, USSR)
ID/WG.44/6 Summary	Summary of the paper POLYESTER-GLASS FIBRES REINFORCE PLASTICS TO STRENGTHEN CONCRETE STRUCTURES - Mr. M.A. Kairi, Ph.D., (Member of the Faculty, Faculty of Engineering and Architecture, American University of Beirut, Beirut, Lebanon) (Main paper restricted, for participants only)
ID/WG.44/7 ID/WG.44/7 Summary	COMPLETION AND SUBSTITUTION OF ASBESTOS CEMENT BY PLASTIC MATERIALS - Dr. H. Schultheis (Leader of Group "Chemical Materials in Building", Farbenfabriken Bayer AG, Anwendungstechnische Abteilung, 509 Leverkusen, Federal Republic of Germany)

Symbol	Title
ID/WG.44/8 ID/WG.44/8 SUMMARY	FIBROUS BUILDING MATERIALS PRODUCED FROM INDUSTRIAL WASTES - Mr. R. Singh (Director, National Buildings Organization, Regional Housing Centre for ECAFE, Nirman Bhavan, Maulana Azad Road, New Delhi, India)
ID/WG.44/9 ID/WG.44/9 SUMMARY	SOME ASPECTS OF THE CHOICE OF ASBESTOS CEMENT MACHINERY - Mr. K. Thiele, (Production Manager, Dansk Eternit-Fabrik A/S, Sohngaardsholmsvej, Aalborg, Denmark)
ID/WG.44/10 ID/WG.44/10 SUMMARY	POLYSAND BUILDING MATERIALS, THEIR PRODUCTION AND APPLICATION - Mr. I. Benedikter, (Consultant, Patentanstalt Für [illegible], [illegible]stein, Burggasse 24, Vienna 1070, Austria)
ID/WG.44/11 ID/WG.44/11 SUMMARY	FIBROUS SUBSTITUTES OF ASBESTOS - Mr. L. [illegible], (Head of Technological Group, Research Institute of Building Materials in Brno, Ostrava, Výstavní 30, CSSR)
ID/WG.44/12	PROVISIONAL LIST OF PARTICIPANTS
ID/WG.44/13	LIST OF DOCUMENTS ISSUED
ID/WG.44/14 ID/WG.44/14 SUMMARY	MINERAL WOOL AND ITS PRODUCTS. PRODUCTION AND USE - Mr. I. Eremin, (Deputy Chief Engineer, Institute of Teploproekt, 7 Kominterna Street, Moscoe, USSR)

Appendix [illegible]

The participants of the meeting had an occasion to see a modern asbestos pipe factory south of Vienna, the Eternit-Werke Ludwig Hatschek in Niedermannsdorf.

Asbestos cement under the name Eternit was invented by Dr. Hatschek in 1899 and patented in 1901. The cradle of this industry is the Eternit plant in Vöklabruck, Upper Austria, which is still the largest asbestos cement production plant in Austria.

The plant located in Niedermannsdorf was erected within an eighteen month period and began production by the end of 19[illegible]. The production line is dedicated to asbestos cement pipes. The annual production rate is 25,000 tons of asbestos pipes with diameters ranging from [illegible] mm to 1600 mm. Of this amount, 40% is exported while the rest is utilized for [illegible] and waste-water projects in Austria. For example, the Vienna water works use 1200 mm pipes in the city's sewage system.

Austria is one of the countries with the highest per capita consumption of asbestos cement sheet goods. 50% of it is corrugated sheets, 35% flat sheets and shingles and 15% decorative materials. Asbestos is imported from South Africa, Canada and the USSR. A six months supply of asbestos is kept on stock at the pipe plant in Niedermannsdorf.

The participants had the opportunity to see the operation of a modern pipe machine and the further processing and testing of high pressure pipes at one of the most modern installations of its kind.

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