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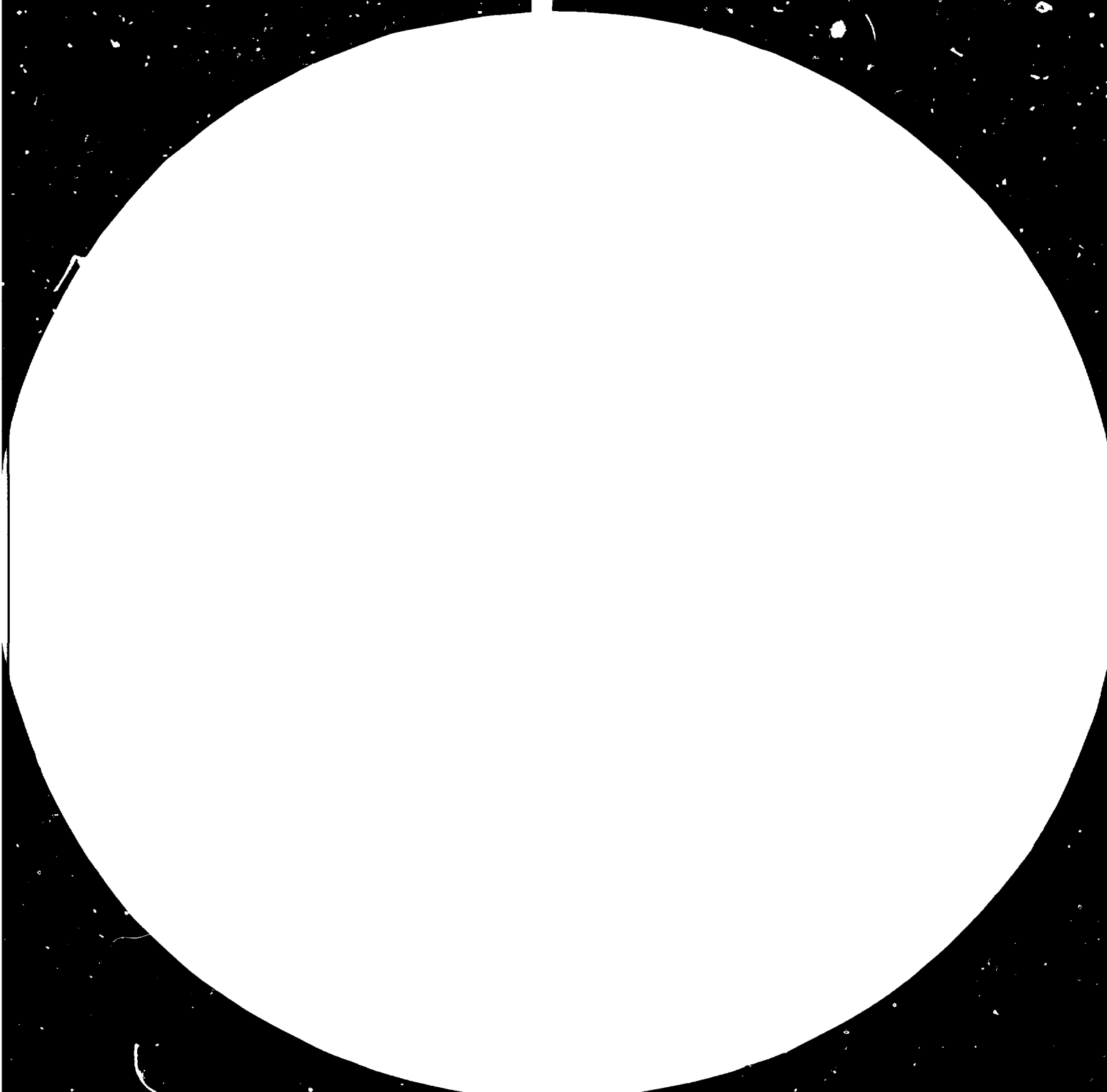

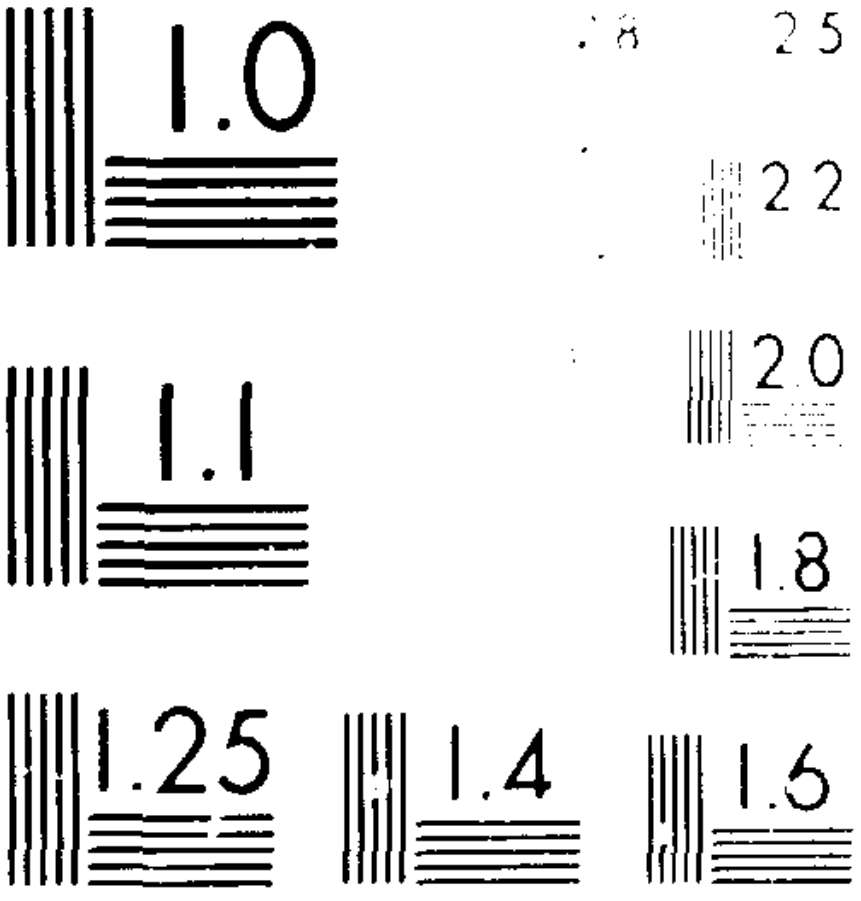
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DP/ID/SER.A/363
11 February 1982
English

IMPROVEMENT OF BUILDING MATERIALS MANUFACTURE

DP/CPR/80/010

CHINA .

Technical report: Establishment of a Research and Development centre for light-weight building materials

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

Based on the work of Sandor Popovics,
adviser on light-weight building materials

003364

United Nations Industrial Development Organization
Vienna

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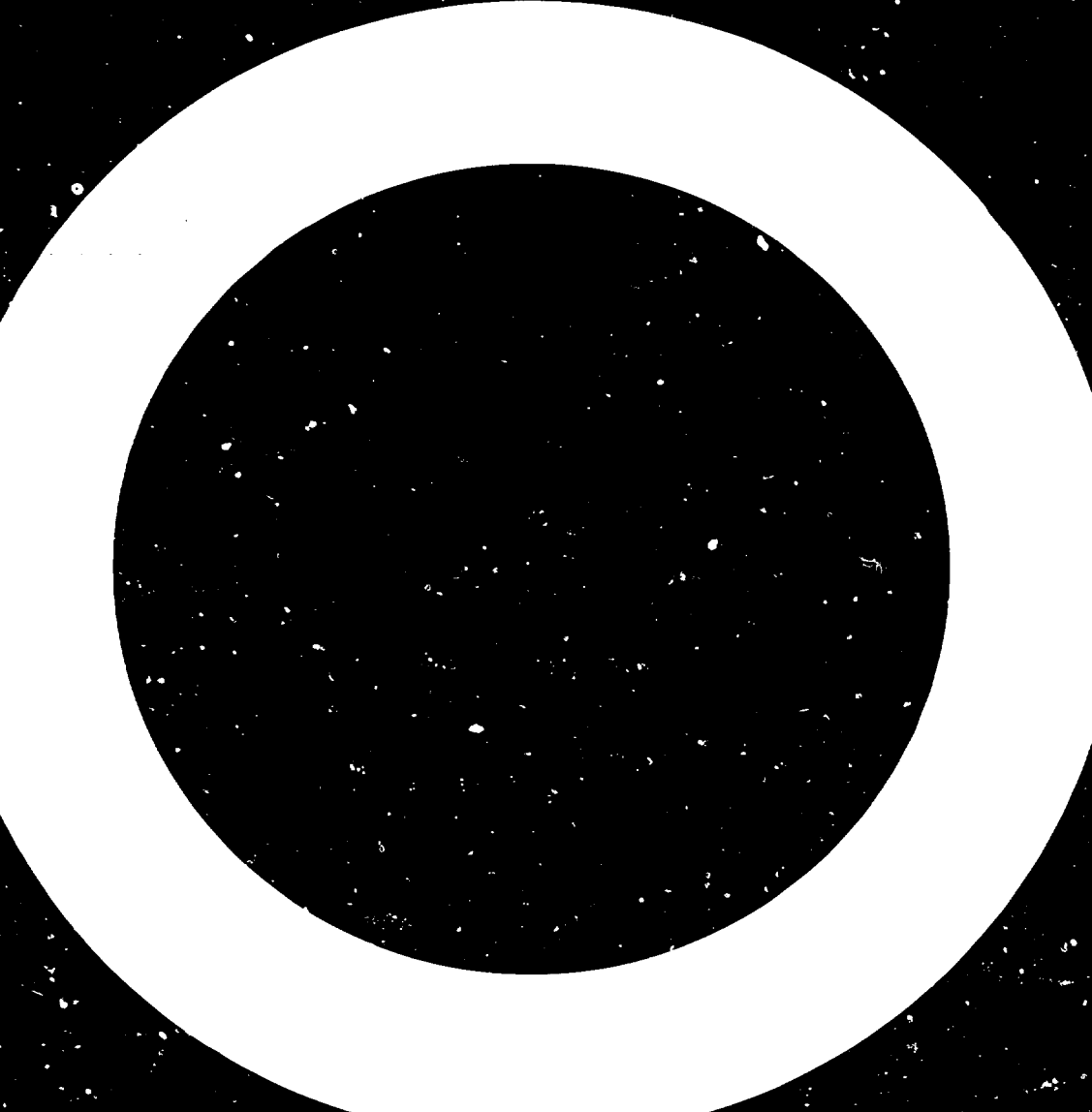
Explanatory notes

Mention of firm names and commercial products does not imply the endorsement of the United Nations Industrial Development Organization (UNIDO).

ABSTRACT

As part of the United Nations Development Programme (UNDP) project "Improvement of building materials manufacture" (DP/CPR/80/010), an expert was sent on a two-part mission by the executing agency, the United Nations Industrial Development Organization (UNIDO), to advise on the establishment in China of a research and development centre for light-weight building materials. During the first part of the mission, from 30 September to 30 October 1981, the expert visited plants and construction sites in Beijing and Harbin, China, in order to get a general picture of the building materials industry there. During the second part of the mission, from 31 October to 23 December 1981, the expert escorted five Chinese technical experts of the Ministry of Building Materials Industry on a study tour first to the United States of America and then to Denmark and the United Kingdom of Great Britain and Northern Ireland. The expert's main conclusion is that the establishment of a research and development centre for light-weight building materials in China is justified and he recommends that UNIDO assist in carrying out such a project.



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INTRODUCTION

At the present time, traditional building materials, primarily clay bricks, are used for the construction of housing in China. The output of clay bricks in 1980 was more than 150 billion pieces and accounted for more than 90% of the walling materials used. However, bricks lack diversity and have low construction efficiency. In addition, the mining of the clay used for the manufacture of bricks consumes large areas of farmland. It is therefore imperative to develop the production of light building materials using other resources, including industrial and agricultural wastes.

As there was no specialized organization engaged in research and development on light building materials in China, the Government decided to establish a research and development centre for light weight building materials in Hangzhou, Zhejiang Province. It will be attached to the existing Design Institute for the Modern Building Materials Industry. The Design Institute, with a technical staff with more than 20 years' experience, formerly specialized in the glass industry but has recently started designing plants for production of plasterboard and polymer building materials. The scientific work of the research and development centre may be combined synergistically with the work of the Design Institute. It is envisaged that the centre (total floor area of 12,300 m^2) will be in operation by 1985 with a staff of 60 in the first stage (to be increased to 150).

To provide a sound foundation for the establishment of a centre, the expert was sent, as part of the United Nations Development Programme (UNDP) project "Improvement of building materials manufacture" (PC/CPR/80/010), on a two-part mission by the United Nations Industrial Development Organization (UNIDO), the executing agency. During the first part of the mission, from 30 September to 30 October 1981, the expert visited plants and construction sites in Beijing and Harbin, China, in order to get a general picture of the building materials industry there. During the second part of the mission, from 31 October 1981 to 23 December 1981, the expert escorted five Chinese technical experts of the Ministry of Building Materials Industry on a study tour first to the United States of America and then to Denmark and the United Kingdom of Great Britain and Northern Ireland.

Research work on light-weight building materials in China does not have a long history. Therefore, it is necessary to:

(a) Carry out more intensive research and development work in this field;

(b) Obtain experimental instruments and equipment from abroad;

(c) Introduce new technology;

(d) Raise the technical level of the existing and future staff through training.

The development ojbectives of the project are to:

(a) Explore and utilize local material resources, including industrial and agricultural wastes;

(b) Promote light-weight multifunctional building materials and elements;

(c) Diversify building materials, improve their architectural functions and increase construction efficiency;

(d) Accelerate the modernization of the building materials industry and the construction industry.

RECOMMENDATIONS

Based on the findings of the study tours, it is recommended that UNIDO assist in the establishment of a centre for research and development of light-weight building materials in China along the lines described in the most recent project document. The additional recommendations presented below are intended to reinforce, clarify, or modify certain details.

1. The centre should consist of three major divisions - applied research, development, and services to the industry representing the three main activities. Each division may have several departments.

2. Research and development on light-weight building materials should be concentrated in the centre, not spread among a number of institutions located in different places. If this is not feasible immediately, plans should be made for the gradual transfer of the major activities to the centre in the near future.

3. Activities not related to light-weight building materials should be reduced to a reasonable level to avoid spreading the available financial and human resources too thin for efficient work. Research and development activities should be focused on concrete, especially light-weight aggregate concrete in the form of panels and hollow blocks. The study tour revealed that hollow blocks are used in larger quantities than other light-weight materials and that their use has been steadily increasing the expense of other light-weight building materials.

4. The Centre should have enough personnel, emphasis being placed on proper professional training. It is especially important that the staff engaged in research have high-level academic backgrounds.

5. For some staff training should be undertaken at schools or industries in China. For others, additional training may come from study tours and short training courses abroad. However, for many research positions long-term post-graduate studies should be undertaken at foreign universities or research institutes. Financing for the foreign training programme might be sought from United Nations technical assistance programmes or from other sources.

6. Instead of sending the students abroad for training, consideration should be given to bringing foreign experts to China to train personnel at their places of work. This would be particularly suitable for training in gypsum-board or aerated (gas) concrete manufacturing.

7. Funds needed to purchase foreign equipment for research and development activities might also be requested from United Nations technical assistance programmes.

8. The Chinese Government should hire foreign experts to help solve specific problems, such as finding appropriate training places abroad or recommending the most suitable equipment for a given laboratory. It is calculated that six man-months per year for the next five years would be necessary for such advisory services.

9. A chief adviser should be assigned to the project to find the experts mentioned above and to co-ordinate their work. An estimated three man-months per year would be needed for the services of a chief adviser.

10. The costs of any new building material should be investigated by comparing it to other existing or new materials for the same purpose. Proper consideration should be given to service life maintenance expenditures, price of construction and all non-tangible but pertinent factors. For instance, the economy of polymer floor tiles should be compared with cement floor tiles made with marble or other stone aggregates, or fibre-reinforced cement panels should be compared with light-weight aggregate panels. Most importantly, the economy of concrete blocks should be investigated in comparison with other wall-forming materials.

I. STATUS OF THE LIGHT-WEIGHT BUILDING MATERIALS INDUSTRY IN CHINA

As the first part of the mission to advise on the establishment of a research and development centre for light-weight building materials the expert made a two-week tour in China at the request of the Chinese Government. The tour included visits to five plants and one construction site in Beijing and to two plants and one construction site in Harbin. In addition, meetings were held with UNDP officials in Beijing. The expert was accompanied on these visits by Mao Wen-Jie and Qu Tong-Zing in Beijing and Mao Wen-Jie and Chang Wang-Chai in Harbin. The comments below are based on information obtained in the plants from discussions with technical and adminstrative personnel.

A. Visits

Experimental plant for modern building materials, Beijing

The plant will eventually have two production lines: one for mineral wool, built by a Swedish company, is already in operation; the other, for paper-covered plasterboard, is being installed by a company of the Federal Republic of Germany.

The expert observed the operation, and examined the final product, of the mineral-wool production line and of those units of the plasterboard production line that had been installed.

Plant for plasterboard production, Beijing

The plant, construction of which started in 1975, has been in operation since 1978. The buildings and equipment are Chinese made. The plant works smoothly but not at its full capacity of 4 million m^2/a for three shifts. The reason for the reduced production is that demand for plasterboard is not great. Demand is expected to increase in Beijing and elsewhere in China after government campaign to popularize this material.

The technical director was not completely satisfied with product quality because one side of the board was not sufficiently plane. He attributed this to the unsatisfactory quality of the domestic paper used. The expert believed, however, that minor changes in the composition of the gypsum slurry (water content, use of a plasticizer etc.) might also reduce this problem.

Plant for the production of aerated concrete, Beijing

The plant has been in industrial production since 1967 under a Swedish license for making aerated concrete of the "Siporex" type (Portand cement binder, aluminium powder, autoclave treatment etc.). The building was erected by the Chinese, but everything else was done by the Swedish company, including the training of workers.

The aerated concrete has a density of 500 kg/m^3 and a compressive strength of 30 kgf/cm^2 (300 N/cm^2) after autoclave treatment. The concrete is used for both reinforced and unreinforced elements. The plant also produces smaller quantities of aerated concrete with a density of 600 kg/m^3. Total production is 240,000 m^3/a in three shifts, although the original capacity of the plant was only 150,000 m^3/a.

The production line is automated to a great extent, following Swedish technology. The plant works smoothly and the product appears to be of good quality.

Plastics plant No. 10, Beijing

This plant has been producing various plastic products (shoe soles etc.) for quite a few years. Two years ago it started making PVC floor covering which at present accounts for 5%-6% of total production. The buildings and the equipment and machinery are Chinese made.

The final product ap- pears to be satisfactory; however, the machinery is somewhat outdated and pro- duction is slow. The management plans to buy a new unit of larger capacity which would significantly increase the output without any increase in person- nel.

Construction of apartment buildings in the mini district Solidarity Lake, Beijing

The total floor area of the buildings will be 490,000 m^2. The expert visited a 12-storey building constructed with pre-cast concrete elements. Several different kinds of floor and wall panels were used without any difficulty, delay or confusion. Construction with the pre-cast elements was problem-free and quite fast using cranes, namely two storeys per week.

A wall-paper factory, near Beijing

The factory buildings were made by the Chinese, equipment and technology were of Japanese origin. Production started in 1979. Both the paper and the plastics used are domestic. Capacity is 10 million m^2/a in two shifts, but actual production is less because of low demand. The factory also produces PVC pipes using Chinese materials, technology and equipment. The manufacture of PVC floor covering (in rolls) with porous internal structure for better sound insulation is also planned.

Aerated concrete plant, Harbin

Industrial production started in 1977. The plant could produce at the rate of 100,000 m^3/a in three shifts in the form of blocks, wall slabs and roof slabs; however, the plant does not work at full capacity owing to lack of demand in the area for aerated concrete. Reinforced pre-cast elements of traditional normal-density concrete are also produced.

The expert observed the equipment and production of aerated concrete elements and concluded that the plant worked as smoothly as the one in Beijing.

Plaster board plant, Harbin

Industrial production started in May 1980. Capacity is 4 million m^2/a in three shifts but production is much less because of lack of demand in the area. Here, again, Chinese officials anticipate a sizeable increase in demand. The technology, machinery and domestic paper used are similar to those in the plasterboard factory in Beijing. The problem is also the same, namely that one surface of the board is not plane enough. This is attributed to the inadequate quality of the paper used and, possibly, to the composition of the gypsum slurry.

There are two other production lines in the factory - one for window frames and the other for "I" profiles from plaster. These two products are manufactured when the plasterboard production line is not in operation.

Construction site, Harbin

Some 24 multi-storey apartment buildings were under construction, of which 4 were made with light-weight pre-cast elements and 20 used traditional brick. The production time of the pre-cast buildings was about one third of that of the brick buildings. On the other hand, the smoothness of the inside brick walls was superior to that of pre-cast plasterboard walls. It was also noted that the wall thickness of the light-weight pre-cast elements was significantly less than that of the comparable brick walls which, of course, increased the useful ground area of the pre-cast buildings.

The expert did not notice any difficulty in utilizing pre-cast elements to full advantage in building construction.

B. Conclusions

Regardless of whether the Chinese light-weight building materials industry continues to emphasize aerated concrete and paper-covered plasterboards, the expert had good reasons to be optimistic about the future of the development of building materials in China. The visits to plants and construction sites convinced the expert that, although clay bricks are still the traditional building materials used, new building materials can be introduced because:

(a) The Chinese building materials industry is capable of adopting and using successfully quite sophisticated technologies, such as the "Siporex" methods to produce aerated concrete for pre-cast elements;

(b) The Chinese construction industry will have no difficulties in using, to a much larger extent than at present, pre-cast elements in apartment houses and industrial buildings.

In other words, whatever results a new research and development centre for light-weight building materials produces, the materials industry and the construction companies will be able to apply these successfully to improve productivity in building.

II. STUDY TOUR OF THE LIGHT-WEIGHT BUILDING MATERIALS INDUSTRY

The study tour of the light-weight building materials industry - beginning in the United States and moving on to Denmark and the United Kingdom - was organized by UNDP and UNIDO in co-operation with the Governments of the three host countries. Five Chinese technical experts of the Ministry of Building Materials Industry (annex I) were accompanied by the expert, whose role was to:

(a) Advise the Chinese participants on the information received and observations made during the tour in order to maximize the benefits from the visits and, especially, to facilitate the integration of the knowledge obtained into the Chinese situation;

(b) Advise the participants about the organization, administration and operation of research and development laboratories dealing with building materials.

One important objective of the study tour was to observe the general trends in the light-weight building materials industry in the United States and then in Denmark and the United Kingdom in order to help organize the research and development center and the Chinese building materials industry as a whole. Therefore, during the study tour materials research and development laboratories as well as industrial plants were visited; laboratory equipment and procedures were studied; manufacturing processes were observed; and discussions were held with research scientists, development engineers, administrators and plant managers, with special reference to the prevailing and anticipated Chinese conditions. Also, pertinent technical and economic data were collected; research, development and application procedures were traced through actual examples; training possibilities were discussed; relation with other organizations were analysed; and organizational aspects were discussed in detail.

A. United States

The study tour in the United States was scheduled to start on the west coast in October 1981. Since, however, the Chinese participants did not receive the United States visas in time, the tour actually started in Cleveland, Ohio, on 11 November and ended in New York on 21 November 1981. The itinerary, the visited organizations and the names of the persons involved in these visits are presented in annex II. The findings are presented below.

Active research has been conducted in several areas of light-weight building materials in the United States. The Portland Cement Association has investigated cement-based light-weight materials; B.F. Goodrich Company has been researching polymeric building materials; Owens Corning Company has been concentrating on glass-fibre reinforced building elements; the National Bureau of Standards has been investigating the whole range of building materials and elements; and the Asphalt Institute has been doing work on bituminous roofing materials. All this research work is applied research, but the organizations involved have good connections with experts doing basic research as well as engineers doing development work and application.

Industrial production observed included manufacture of light-weight aggregates and light-weight aggregate concrete blocks in Maryland; construction of a housing project in the Bethesda, Maryland, area; and manufacture of paper-covered gypsum boards in the US Gypsum plant in Philadelphia, Pennsylvania.

The purpose and activities of the laboratories of the Portland Cement Association are more or less similar to those visualized for the proposed research and development centre for light-weight building materials in China. Thus, it was useful to note the organization, administration and operation of this organization. The expert found particularly important the high professional level required from the research and development personnel as well as the co-operation between the different divisions of Portland Cement Association.

Conspicuously absent from the research, development and application seen in the United States was cellular (gas and foam) concrete. Many years ago there was a limited amount of research and development work that resulted in the limited production of cellular concrete blocks and elements. However, production stopped around 1960 and since then neither research and development nor production have been done. It appears that the United States construction industry prefers materials stronger than cellular concrete for load-carrying purposes, and other materials that are more efficient than cellular concretes for insulation purposes.

The most widely used light-weight building element on the North American continent, is the concrete block. Since it is very likely that blocks may also play an important role in China, some of the advantages of this building element are presented below.

The popularity of concrete blocks (made with light-weight aggregate concrete or normal weight concrete) can be attributed to the combination of the following factors:

(a) The machinery and other equipment needed for production of concrete blocks is small and relatively inexpensive, with low energy consumption;

(b) The operation of the machinery is simple therefore it is easy to train personnel for the job; consequently, inexpensive labour can be employed;

(c) There is a wide variety of raw materials that are suitable for the production of concrete blocks. These include natural light-weight aggregates such as pumice, expanded clay and slate and fly ash. Therefore, local resources can be fully utilized and, consequently, small enterprises for block manufacturing can be economically established in many places to fulfil smaller local construction demands;

(d) A variety of different light-weight concretes can be produced from the same available materials simply by changing the proportion of the natural sand in the concrete. Therefore, the diverse geography and environments as well as economic and cultural demands in various parts of China can be taken into consideration;

(e) Minor fluctuations in the quality of the conrete ingredients do not influence excessively the quality of the concrete or concrete block;

(f) It is possible to produce hollow concrete blocks to further reduce the weight of the block. Even normal-weight concrete can be used for block production, as demonstrated by many block producing plants in the Western world;

(g) The construction technique using blocks is similar to that using bricks. Therefore, the transition from brick construction to concrete block construction will be relatively easy.

B. Denmark and the United Kingdom

The Danish tour was mostly industry-oriented, while the tour in the United Kingdom was predominately research-oriented. During visits to research laboratories, a university, and industrial plants pertinent problems were discussed with experts. The tour lasted from 25 November to 5 December 1981 in Denmark and from 6 to 18 December 1981 in the United Kingdom. The intinerary, the organizations visited and the names of the persons involved in these visits are presented in annex II. The summary of findings is given below.

The most widely used light-weight building element in Europe is again concrete blocks. Nevertheless, in contrast to the United States, there is aerated concrete manufacturing in Europe but it is on a limited scale, and there seemed to be little research activity in this area. Otherwise the visits in these countries were similar to those in the United States.

Intensive research activity on light-weight building materials and elements was observed in the pertinent laboratories of the Building Research Establishment in Watford, and in the Civil Engineering Department of Sheffield University, Sheffield, in the United Kingdom. Activities in both places can be categorized as primarily applied research with strong ties to basic research and with less connection to the industry. Research and development laboratories which were part of manufacturing companies were also visited. Their activities were naturally restricted to the product areas of the host companies. They have provided useful results for the companies through applied research, development and application within this framework but they have not been involved in basic research to a large extent. The expert was particularly impressed with the laboratories of John Laing, Ruberoid Ltd. and the Pilkington Companies in the United Kindom, and the laboratories of H+H Industry in Denmark. These laboratories are good examples of what a well-organized and properly equipped and staffed technical laboratory can do for the improvement of existing products and development and application of new products. The industrial production observed was similar to that in the United States. This included manufacturing light-weight aggregates and light-weight aggregate concrete elements in Glostrup and an aerated concrete factory in Olsted, Denmark and manufacturing paper-covered gypsum boards in Sherburn, bituminous roofing materials in Brimsdown, and glass fibre reinforced cement elements in St. Helens, United Kingdom. Experts from these plants, if invited, could help the exiting Chinese building materials industry in these specific areas.

Altnough the administrative aspects of the research and development activities were discussed in the various laboratories, these are only indirectly applicable to the proposed research and development centre in China owing to the differences in the purposes of the laboratories in China and in Europe.

III. PROPOSED ACTIVITIES OF THE RESEARCH AND DEVELOPMENT CENTRE FOR LIGHT-WEIGHT BUILDING MATERIALS IN CHINA

Based on the findings of the mission, it is recommended that the centre be divided into three divisions - namely research, development and services. The suggested activities of each division are described below.

A. Research

Research activity in the centre will be essentially applied research. This activity bridges the gap between basic, or fundamental, research (performed elsewhere) and the development on light-weight building materials. This means that results of pertinent basic research will be obtained from an academic or other research institute; the practical applicability of these results will be checked on a laboratory scale; if the findings are encouraging further work will be done to improve applicability; and recommendations will be worked out for development on a larger, semi-industrial scale.

B. Development

Development will be the stage between the applied research described above and full-scale industrial application. Promising results from the research activities of the centre will be tried out on a semi-industrial scale; optimum modification of the laboratory methods made necessary by the increase in scale will be established; and, if the findings are encouraging, recommendations will be given for a full-scale industrial trial. The recommendations would include machinery and equipment needed for the production of materials as well as for the design and construction of the buildings utilizing these materials. Training construction industry personnel to adopt the new materials and methods can also be the responsiblity of the centre.

C. Services

Service activities can be divided into two groups, namely external service and internal service. External service includes, among others, training personnel for production, quality control, and application of light-weight building materials and elements; solving local technical problems of production plants; training people in the construction industry as well as contribution to the design of buildings and construction machinery for the proper utilization of new light-weight materials and structural elements. The internal service includes all the administrative and supplementary scientific and technical activities that are needed for the smooth and efficient running of the centre. Such activities are: general administration, personnel, bookkeeping; library, computer centre; maintenance of the equipment, machine shop.

It follows from the nature of the service activities that this division should have an intimate contact with the other divisions in the centre.

Annex I

STUDY TOUR PARTICIPANTS FROM
THE MINISTRY OF BUILDING MATERIALS
INDUSTRY, BEIJING

Qu Fei, Director, Bureau of Local and Modern Building Materials

Qu Tongxin, Engioneer, Deputy Directory Bureau of Local and Modern Building Materials

Wang Mengyan, Engineer, Project Deputy Director

Chen Yan, Engineer, Bureau of Local and Modern Building Materials

Mao Wenjie, Engineer, Modern Building Materials Industry Design Institute

Annex II

STUDY TOUR VISITS

Place visited	Date	Persons contacted
United States		
B.F. Goodrich (BFG) Research and Development Center, Brecksville, Ohio 44141	2 Nov. 1981	Krishna Baranwal, Manager, Technology Assessment Charles P. Gambrill, Manager, Export Sales, International Division R.J. Straight, Jr., Sales Product Engineer, International Division
Portland Cement Association (PCA), 5420 Old Orchard Road, Skokie, Illinois 6007	4-5 Nov. 1981	James I. Daniel, Associate Structural Engineer J.J. Furco, Eivind Structural Engineer Eivind Hognestad, Director Albert Litvin, Concrete Materials Research Department
Owens Corning Fiberglass Technical Center, Granville, Ohio 43023	6 Nov. 1981	D.P. Anderson, Manager Robert S. Blancett, Supervisor Harold A. Dewhurst, Director Robert L. Houston, Manager
American Society for Testing and Materials (ASTM) 1916 Race Street, Philadephia, Pennsylvania 19102	9 Nov. 1981	Peter Brown

Comments

The session included a slide presentation and discussion of B.F. Goodrich's testing and production of light-weight building materials. A guided tour in the BFG Technical Center near Avon Lake was given.

The two-day visit contained slide presentations concerning the activities and operation of PCA; a presentation on the use of light-weight building materials and elements; and guided tours in the various research and development laboratories

The visit included slide presentations on the activities, operation and management of the company; guided tours in the laboratories of the company; and discussions on the development, production and testing of fiberglass-reinforced building materials.

A lecture with slides concerning the activities of ASTM in general and the voluntary standardization process in particular was presented.

Drexl University, Department of Civil Engineering, Philadelphia. Pennsylvania 19104	10 Nov. 1981	Paul Deery, Research Engineer Harry G. Harris, Professor Robert M Koerner, Professor Bernard M. McNamee, Chairman Sandor Popovics, Professor
National Association of Home Building, 15th and M Street, N.W., Washington, D.C. 20005	12 Nov. 1981	Stephen C. Moore, Program Manager for Architectural Engineering and Design
Expanded Shale, Clay and Slate Institute, 4905 Del Rey Avenue, Bethesda, Maryland 20814	13 Nov. 1981	Harry C. Robinson, Managing Director
National Ash Association, 1819 H Street, N.W., Washington, D.C.	13 Nov. 1981	James Convey, Executive Diretor Stephen Gillis, Staff Engineer
National Bureau of Standards, Gaithersburg, Maryland	16 Nov. 1981	Robert G. Mathey, Office of International Relations C.C Raley Walter J. Rossiter

Professor McNamee gave a general introduction about the research activities in the Department; Professor Koerner talked about the geo-technical activities; Professor Harris about earthquake engineering; and Professor Popovics about building materials research in general, and research in light-weight materials, cement, flyash and concrete in particular. The willingness of Drexel University to accept qualified Chinese personnel for medium- and long-range academic training was also pointed out.

A guided tour the visit through the materials laboratories as well the Roofing Institute of Drexel University was given.

A lecture on the role, activities and operation of the Association were given.

Research in the field of light-weight building materials as well as the organization and activities of the Institute were discussed.

The organization and operation of the Association were discussed.

The organization and general activites of the Bureau were described followed by tours of the Structural Bureau and the laboratories for building materials and a discussion on roofing materials.

Asphalt Institute, University of Maryland Campus, College Park, Maryland 20740	17 Nov. 1981	John Bukowski, Engineer Staff Assistant	The organization and role of the Institute and the ongoing research in the field of bituminous materials, especially roofing materials, were discussed, followed by a guided tour of the laboratories of the Institute.
Lightweight aggregate and lightweight aggregate concrete production near Bethesda, Maryland	18 Nov. 1981	Harry C. Robinson	Mr. Robinson arranged trips in the Bethesda area to plants manufacturing expanded light-weight aggregate and light-weight aggregate concrete.
United States Department of Labor, Office of Foreign Labor Affairs, 3rd and Constitution Avenue, N.W., Washington, D.C. 20210	19 Nov. 1981	Glenn Halm, Area Advisor for Far East and Pacific Affairs	Mr. Halm discussed United States-China labour relations with the group.
United States Gypsum Company, 56th and Schuylkill River, Philadelphia, Pennsylvania	23 Nov. 1981	George Boggia, Works Manager	The organization and operation of the plant were described and the paper-covered gypsum boards manufacturing plant was visited.
Denmark			
Ministry of Foreign Affairs, Asiatisk Plads, Copenhagen	30 Nov. 1981	Anni Crawshaw Torben Egede (Ministry of Housing)	The programme of the visit was discussed. Mr. Egede also guided the group on a tour of new non-profit housing projects south and south-west of Copenhagen.
Dansk Leca A/S Paul Bergsoesvej 17 2600 Glostrup	2 Dec. 1981	O. Heins Petersen, Pland Engineer Kai Thastum, Managing Director	The production of an expanded clay light-weight aggregate was discussed and the production line was also shown. Trips to Farup Beton, a small plant for the production of light-weight blocks, and Hojslev, to see the industrial production of light-weight aggregate blocks and sandwich slabs and other light-weight elements were organized.

H+H Industri A/S, 3310 Olsted	3 Dec. 1981	Jorgen Elm, Civil Engineer Sven Jensen, Production Manager Poul Claudi Johensen, Civil Engineer
Larsen and Nielsen, Datavej 44, 3460 Birkerod	4 Dec. 1981	Svend Erik Joregenson, Civil Engineer
United Kingdom		
Building Research Establishment, Bucknalls Lane, Garston, Watford, Herts WD2 7JR	7 Dec. 1981	P.J. Nixon A.J. Majumdar V. Dembo
Sheffield University, Sheffield 11	8 Dec. 1981	T.H. Hanna B. Hobbs R. Jones D.A. Nethercot R.N. Swamy A.J. Watson

The activities of H+H industry were discussed in general and a guided tour of the gasbeton factory was given. It was interesting mainly because it uses a technology similar to that used for industrial production of gasbeton building elements in some Chinese Factories. The central laboratory of the gasbeton factory was also visited.

Activities and products of the company of the company were discussed and there was a guided tour along the production line and in the laboratory.

After a general introduction, Dr. Nixon delivered a lecture on building materials from industrial wastes; Dr. Majumdar presented a lecture on fiber reinforcement and gave a guided tour of the pertinent laboratories; and Mr. V. Dembo discussed how the results of the Building Research Establishment are disseminated and applied in the industry.

Professor Hanna, Head of the Department of Civil Engineering, described the organization of research work within his department. The other staff members discussed cementious materials, particularly those strengthened by various fiber reinforcement; the high rate of loading of materials to simulate impact explosions and earthquakes; strengthening deteriorated structures particularly by attaching steel plates to bridge decks; the demolition and damage problems to structures with particular reference to ladding of

			buildings. In addition, the staff demonstrated the use of polymers, particularly Netlon, in structural engineering because much of this work is directly related to the development of light building materials.
British Gypsum Ltd, Sherburn in Elmet, Yorkshire	9 Dec. 1981	Dave Pougher, Sales Manager Bill Weir, Manager	The activities of this manufacturing company were described. The guided tour was of interest because there is a sizeable gypsum board manufacturing industry in China.
John Laing, Research and Development, Manor Way, Borehamwood, Herts WD6 1LN	10-11 Dec. 1981		The organization and management of the research activities in the company were discussed and a slide presentation illustrated some of the light-weight materials products developed. Visits to laboratories and plants were planned for the second day but had to be cancelled because of bad weather.
Ruberiod Building Products Ltd., Brimsdown, Enfield, Middlesex EN3 7PP	15 Dec. 1981	Roger L. Bonafont, Director of Research and Development Keith Curtis, Export Director R.J. Morrow, Technical Adviser F.J. Myers, Chief Engineer in charge of the machinery W.A. Robb, Production Manager	This company produces a wide variety of roofing materials including polyester-based plates, paper- and rag-based plates and similar products. They produce approximately one-third of the roofing materials in the United Kingdom. After the discussion of the types and quality and applications of the product, they showed the impressive research laboratory.

Pilkingtons, Prescot Road, St. Helens, Merseyside	16-17 Dec. 1981	Regi W.K. Cook Richard Ferry Ken L. Litherland Ian J. Morrison

A film presentation on the application of glass fiber reinforced concrete in architecture opened the visit. Subsequently discussions centred on: research and development studies on AR fiber and glass fiber reinforced cement procedures; general principles of design with glass fiber reinforced cement; processing techniques applied to glass fiber reinforced manufacturing; and applications of glass fiber reinforced cement. In the afternoon the Cemfil glass fiber reinforced cement processing was demonstrated in large scale, as well as glass fiber reinforced cement product testing. The headquarters of GRC Limited were also visited, where the organization and activites of the company as well as other activities were discussed.