Contribution of aluminium to the development of large scale building construction in France

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SYNOPSIS

Traditional methods are insufficient to meet the present day needs of buildings and lodgings and the solution lies in the industrialized construction of buildings. Aluminium due to its versatile properties is considered one of the best materials for building construction and is specially suitable for large scale works. In this paper, four examples have been quoted which show that aluminium can be utilized in a way economically acceptable which should, however, be judicious by way of extensive surveys so as to result in reduction of the work on the spot, rational assembling of standardized parts mass-produced in industrial plants.

BUILDING construction in France represents an annual financial turn-over of about 30 billion francs which places this industry in the second rank, next only to agriculture; building construction has however remained an art based on traditional methods inherited from an ancient past.

A parallel is often drawn between the building and automobile industries: in 1914 the cost of a medium sized car was about twice that of a medium sized dwelling house; to day the house costs nine times as much as the car.

To meet the present requirements it is necessary to take up construction work on an industrial scale. This change from old to new methods will no doubt extend over a long transition period but it has already started in France several years ago, showing the necessity of new thinking, accurate estimation, experimentation and smooth continuity of operations, if practical feasibility is to be achieved.

Choice criteria being different, building materials will have to change. Aluminium is comparatively new in the building field but judging from some of the experiments carried out in France, it certainly offers great possibilities for mass-scale construction work.

It is well known that aluminium and several of its alloys have certain properties which make them eminently suited for building work:

- —Excellent atmospheric corrosion resistance due to protection by the thin alumina skin which forms on the surface of the metal.
- —Great versatility.
- —Good appearance and possibility of varied and artistic surface finishing.
- —And finally a number of other properties such as low emissive power, high reflectivity, very good thermal and electrical conductivity, etc.

With these advantages aluminium units progressively appeared on the market and competed with traditional materials. At the initial stages, shape, function and even appearance of the old products were straightaway copied but soon designs were improved and original units were created making the best use of the advantages offered by aluminium. This is why the entry of aluminium in building works was slow in the beginning whereas at a later stage it captured the field at remarkable pace. Its main uses are for:

- —roofing
- —siding
- —windows, doors, curtain walls and facade panels
- —sun shades and shutters
- —banisters, balconies, balustrades
- —partitions
- —false ceilings
- —hardware and decoration products
- —structures
- —miscellaneous, such as for radiators of central heating, fin convectors, fume ducts, hot air, ventilation and conditioning conduits.

Aluminium offers the following special advantages for

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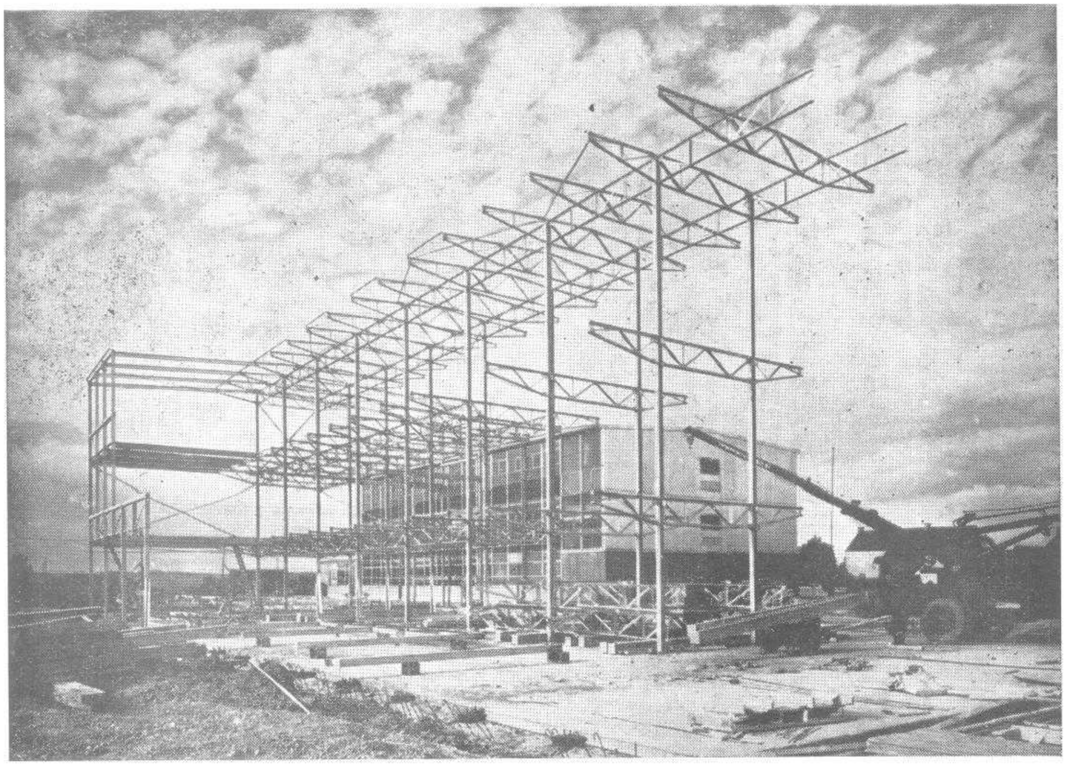
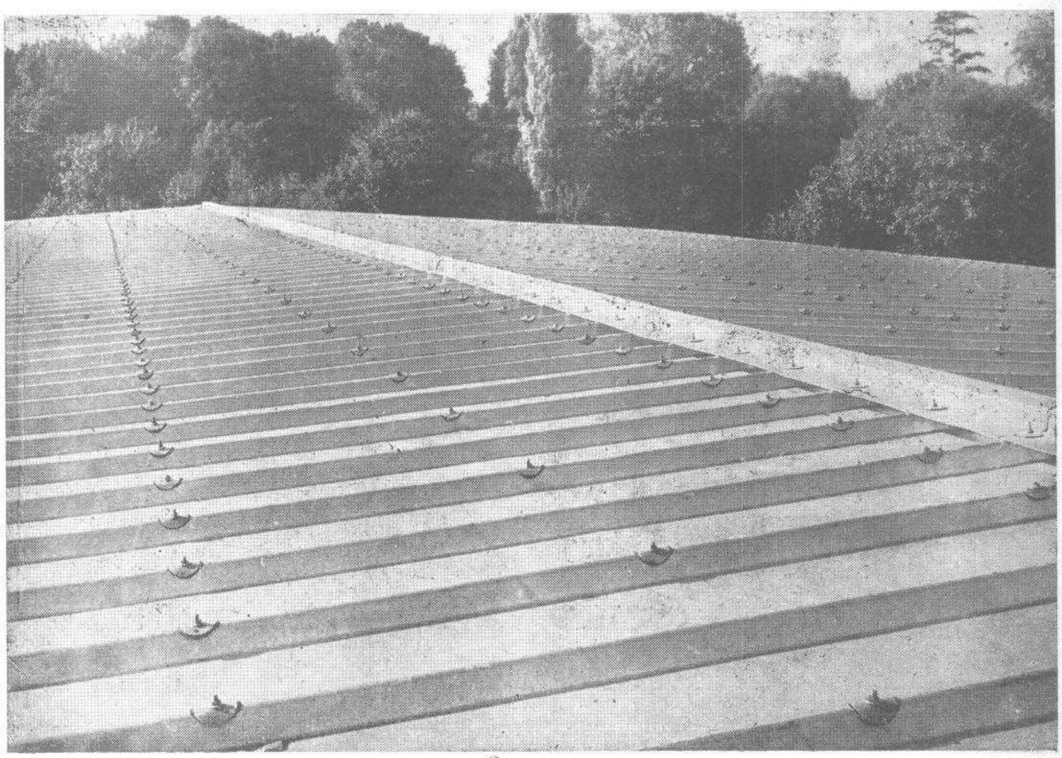
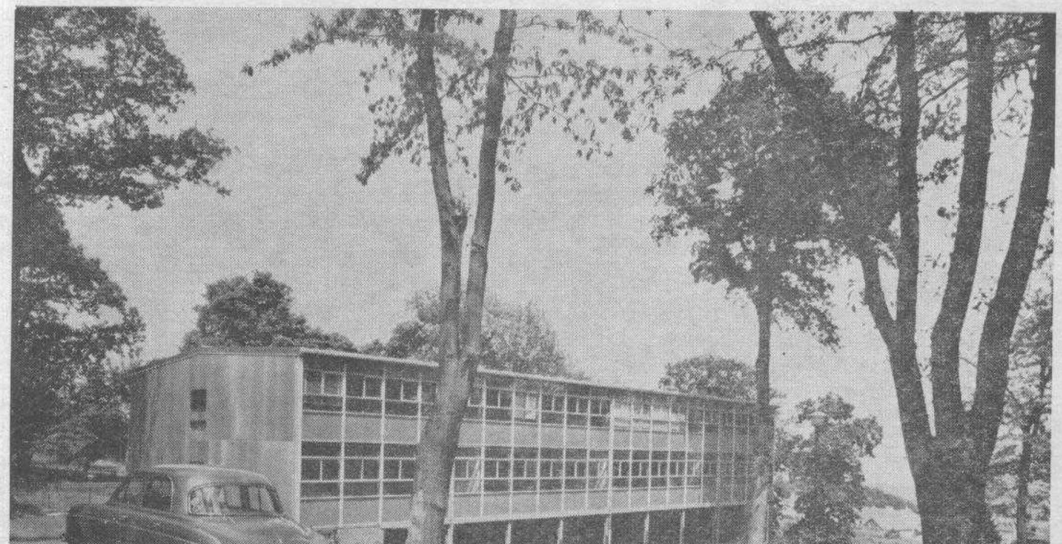


1 *Structure of school building*

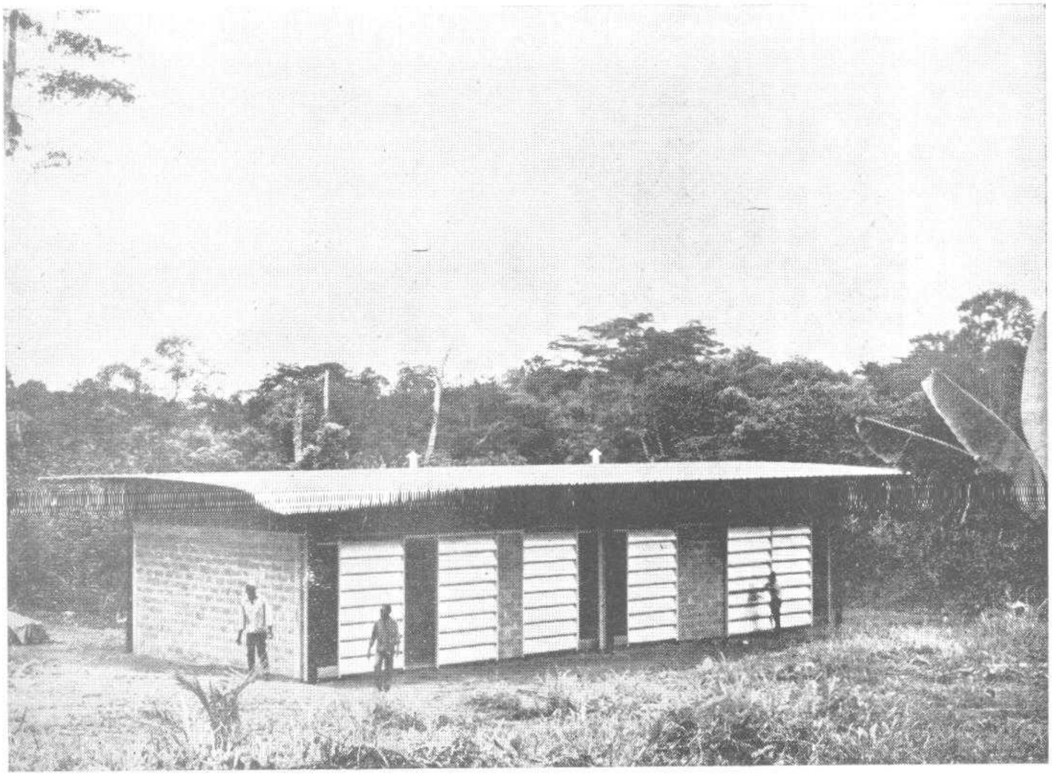


2 *Aluminium roof*

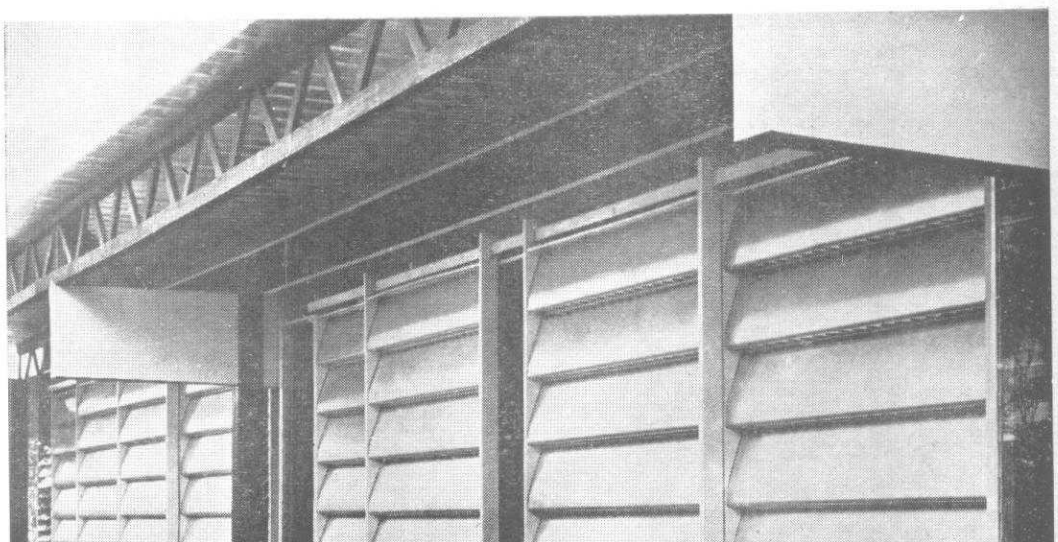
3 *Aluminium false roof*



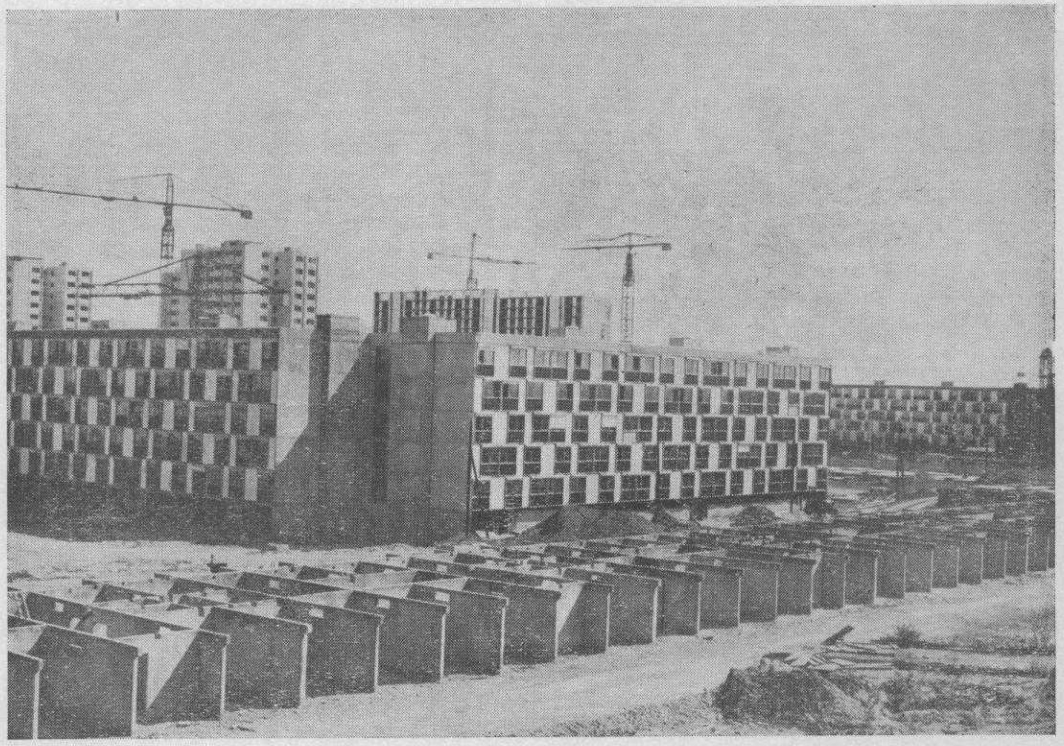
4 *View of completed school building*



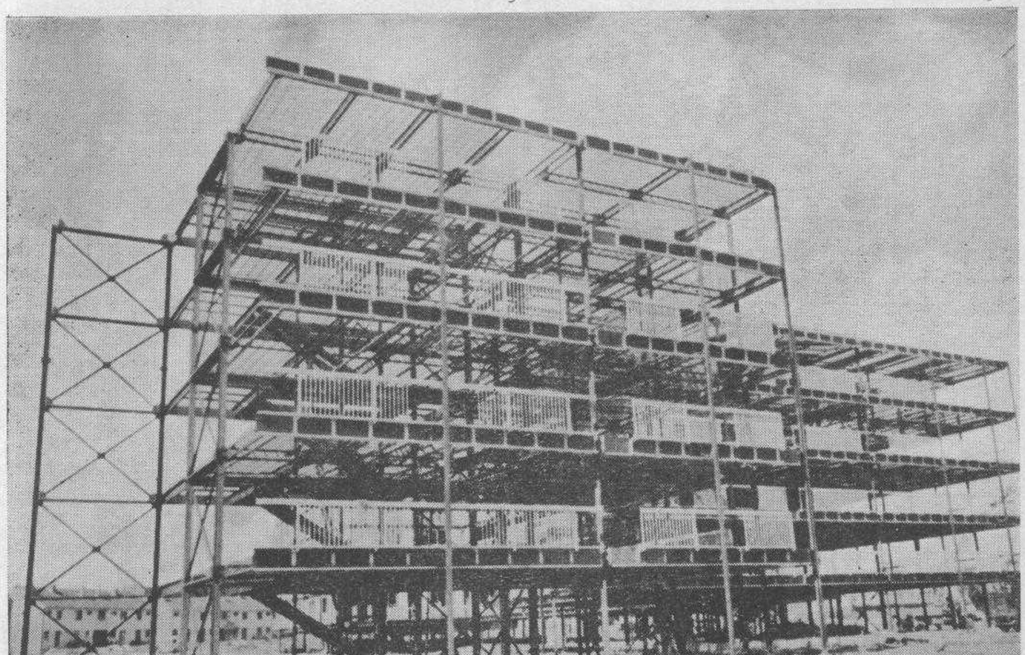
5 *2-class-room school built in Cameroons*



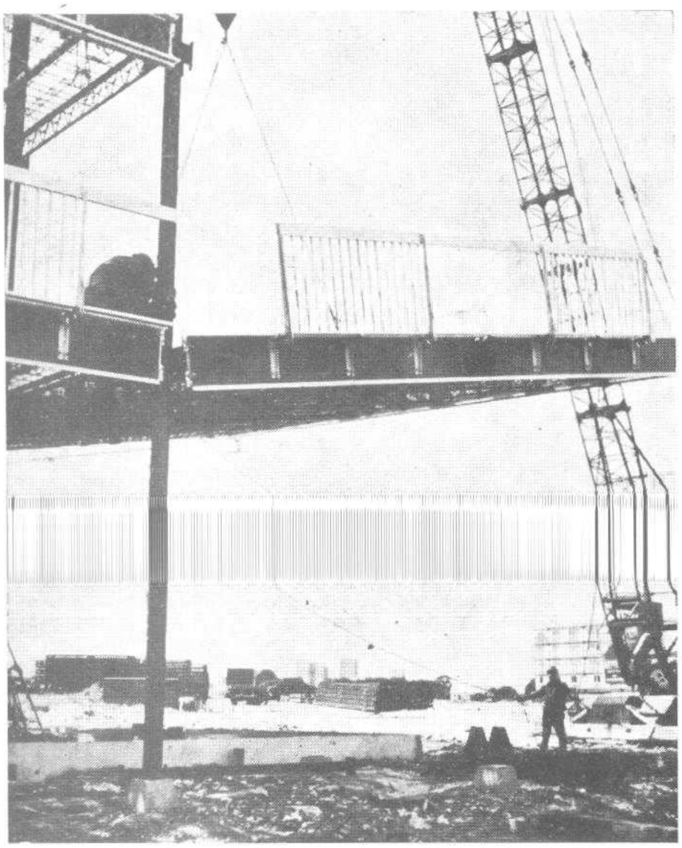
6 *External walls made of aluminium*



7 *Multi-storied residential buildings*



8 *Steel structure*



9 *Floor being laid in position*

the production of prefabricated units employed in mass-scale building works :

- —easy machinability, possibility of casting intricate parts, easy shaping from sheets and strips
- —possibility of large extruded parts (sheets, strips, extrusions)
- —great alloying possibilities to meet various uses and requirements
- —ease and accuracy in assembling to close tolerances
- —the metal is light in weight and non-brittle which is of special advantage for transportation and handling.

These properties had drawn the attention of constructors who since 1950 were concentrating on the question of prefabricated buildings. It was realised that these advantages could compensate the cost difference between aluminium and the standard building materials which are difficult to machine, often brittle, and in any case heavy and difficult to transport and handle.

The following is a brief description of a few experimental construction jobs carried out in France with the collaboration of the Aluminium Industry in the design as well as execution of the work.

Multi-storied schools in France & Benelux (GEEP)

Construction of multi-storied schools seemed to be one of the most accessible jobs for large scale operation. Owing to destructions during the war, population migration and unprecedented demographic growth which followed the end of hostilities and also the raising of age limit for compulsory schooling, our county had to undertake since 1950 a huge construction programme for which important credits were provided. These buildings had to be well finished and the cost estimates permitted the use of quality materials on a rational basis. As standardization was desired, the Government authorities defined a common module and all school building dimensions had to be multiples of this module.

In 1958 the design of a multi-storied building in standardized prefabricated units was undertaken by the architects Messrs. BELMONT and SILVY. They first built in 1959 a prototype with 18 classrooms in Chaville in the suburbs of Paris.

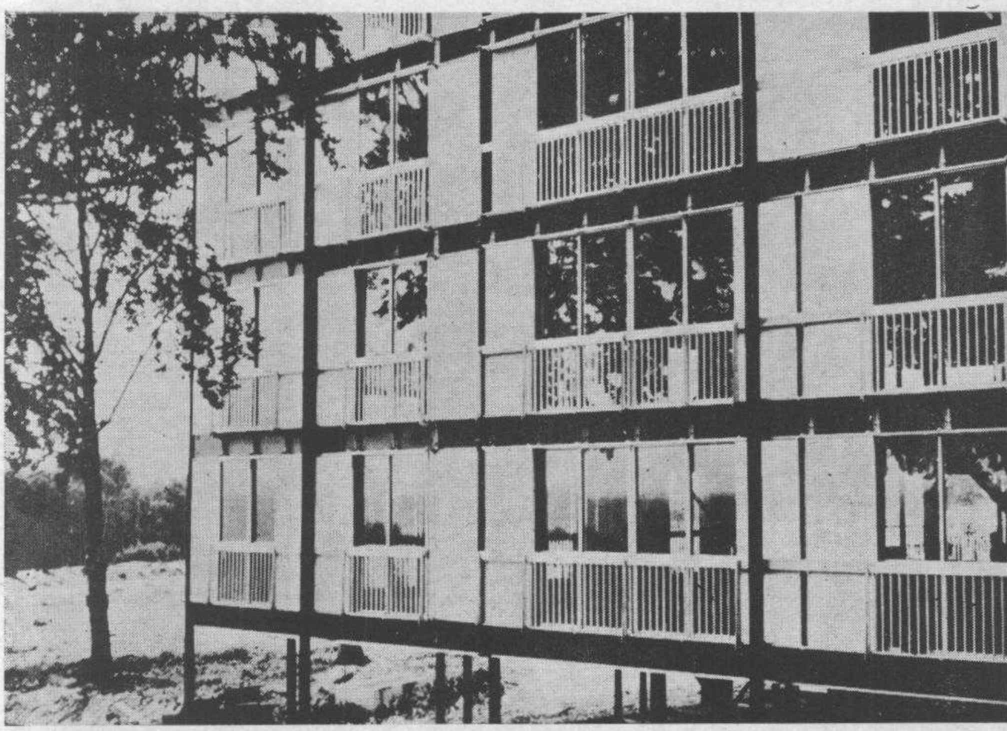
The main idea was to build the classrooms on the upper stories on either side of a central passage, the ground floor being reserved for special purposes as required in individual cases. The structure of the building has been designed in steel and for ensuring flexibility in adaptation to various requirements, it has been decided to realize it from light identical prefabricated units placed at every module of the facade (Fig. 1).

The roof is constituted by ribbed members formed with continuous roller machine from strips and supplied in the exact required length which corresponds approximately to half the width of the building since the roof has two slopes (Fig. 2). Erection is extremely rapid, and the roof can be laid as soon as the structure is completed so that the remaining work can be carried out under shelter. This technique can be used for other mass scale construction jobs. All roof accessories : corner-rafters, gutters, rain-water pipes are in aluminium, prepared in shop and easily fitted with the help of a few welders for assembling watertight parts ; welding is done by oxy-acetylene torch which proved to be the safest and the most simple method on site, for quick training of welders.

Facades comprise curtain wall prefabricated units entirely produced, assembled and glazed in plants ; they are very light because once placed in position they rest on the steel structure which has the same module. Gables, in the prototype were realized in composite solid panels : reconstituted wood, expanded polystyrene, aluminium. Later they have often been replaced for esthetic reasons or for integration with the environment, by usual panelling work which have cost more and brought difficulties in planning ; finally they have been realized as far as possible as siding, i.e. prefabricated units of great lengths prepared in shop, similar to the roof members.

Ceilings are also realized in aluminium from prelacquered and perforated strips formed with the roller machine to the exact required lengths. Assembling is very quick and acoustic correction of the classroom is very effective (Fig. 3).

Other utilizations of aluminium are for radiators of central heating with hot water, hardware, rolling shutters, venetian blinds, etc. The average quantity of aluminium used per classroom has been estimated at 500 kg.



10 *Aluminium facade*

Work on the prototype was started in April 1959 and the building was ready for use on September 15th of the same year. The second prototype was started in July 1959 and inaugurated in November 1959 (Fig. 4).

As more and more buildings were constructed certain modifications and improvements were made and with the experience gained on numerous and large undertakings it was possible to reduce costs in general and to appreciably improve the quality of buildings.

In Benelux, about 800 classrooms were built by this method. Such school buildings have also been realized in other countries: Italy, Spain, Germany and Greece. But it is in France that the development has been important. The number of classrooms built annually passed from 300 in 1961 to 2 000 in 1967. After the construction of elementary schools, classrooms of secondary schools, and even university buildings have been taken up by this method, with slight modifications. For example a University for 7 000 students covering 30 000 m^2 of floors has been built by this process, near Paris, within 90 days.

Schools in Cameroons

This was a different type of job consisting of small units of 1 to 2 classrooms together with a house for the schoolmaster, all single storied. The materials had to be standardized to the maximum to enable work in remote areas and to adapt to various climatic conditions.

The project included the construction of 638 classrooms of elementary schools and 530 houses for schoolmasters. The design and study of these buildings were made by the architects Lagneau, Weill, Dimitrijevic and partners in 1965 and international consultation was open.

As per the specifications the building was to be a light structure, either in wood, or in steel. The wood version has been realized in Cameroons and the steel version which was adopted in about 25% of the cases was based on partial use of imported prefabricated units.

From the very beginning aluminium was the material considered suitable to meet the requirements of the project and a detailed study of its utilization gave rational and economical solutions which helped considerably in this competitive field where cost factors were of predominant importance.

The roof forming parasol and rain-cap has been realized in ribbed members of large dimensions, supplied in suitable lengths and made in Cameroons by roller forming from metal strip. The covered surface represents 108 m^2 for the classroom as well as for the house (Fig. 5).

Above the false roof also in aluminium, a large air space has been provided to ensure good air circulation below the roof.

Outside walls were made of prefabricated wooden panels lined with horizontal aluminium plates designed specially to ensure good transverse ventilation and lighting (Fig. 6). At places, windows with pivoting horizontal plates of glass or aluminium have been provided. Finally, certain gables or inside partition members were in parpen produced on site. Approximately 360 kg of aluminium have also been used for each classroom and 430 kg for each house.

House construction (GEAI)

In France, as in other countries there is a very great need for houses and in this field also, it appears that the solution lies in mass scale construction work especially for residential blocks which are built with State subsidy in view of their acute shortage.

The construction of standardized individual houses, assembled on the spot from prefabricated units prepared in plants has been considered and realized. It was found that aluminium can be widely used in an economical way. However, the present trend in France appears to be towards the construction of large blocks of flats which proves more economical.

In the construction of such buildings in concrete, aluminium can again be used for doors, windows and curtain walls. For example, in the SGAF-BEUFE process adopted at present for the construction of more than 4 000 apartments, the average utilization of aluminium is of 250 kg per flat (Fig. 7).

The GEAI process is quite different. The design work started in 1962 by the architects: Messrs LODS, DEPONDT and BEAUCLAIR and a manufacturers' association. The objective was the construction of collective lodgings with the maximum of prefabricated units produced in plants but allowing for wide adaptation to various schemes and environments. It was thought that the gain obtained by mass scale production would ensure for the same total cost, better quality, comfort and living space and also a reduction in construction time.

For this purpose use of concrete was ruled out because of its weight and difficulty in transportation. The process is characterized by tridimensional steel structures of very wide spans providing adequate clear space for planning out individual flat as per requirements (Fig. 8).

It is not proposed to describe here in details the whole process which has several special features particularly with regard to the construction of floors and roofs.

Floors and all other parts are brought near the building under construction and erected in a few minutes by means of a single crane (Fig. 9). The building is then completed starting from the top : first the roof, which is made of long aluminium members with big ribs (6 cm deep) because the slope is very steep. Laying is done very rapidly on wooden rafters allowing for thermal cutting. The facades are then placed. They are simply fastened to slides and sections set up on the floors, the accuracy of assembly being sufficient for such erection. Prefabricated facade units are solid panels consisting of an assembly of glued materials, the outside being a lacquered aluminium sheet 0·75 mm thick. They also had glazed sliding windows allowing the entire opening of the bays to be realized from extruded sections in anodized A-GS and sliding shutters in prelacquered aluminium sheet 0·5 mm thick including stiffening-ribs. (Fig. 10).

A first prototype of four apartments was erected at the beginning of 1966 in Paris area ; the soundness of the design could be tested and certain modifications made. A construction work of 500 flats is nearing completion in Rouen where 25 four-storied blocks have been erected. The work is progressing satisfactorily, the only real difficulties coming from what remains traditional, i.e. from ground preparation.

Aluminium is being used to the extent of about 530 kg per flat. From the very beginning it has been possible to keep costs within the limits prescribed by the State.