PORT AND OCEAN ENGINEERING UNDER ARCTIC CONDITIONS
TECHNICAL UNIVERSITY OF NORWAY

PREFABRICATION IN HARBOUR CONSTRUCTION WORKS - WITH SPECIAL REFERENCE TO CONDITIONS IN GREENLAND.

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INTRODUCTION

The following paper will present some comments concerning prefabrication and industrialisation of components in the field of harbour and coastal engineering.

Doing this is partly on basis of our experience as consulting engineers in harbour engineering in Greenland and partly on basis of our experience from the design of industrialised housing-schemes in Denmark and Western Germany.

Before the discussion of what sorts of facilities we need in the arctic and of the possibilities for development of standard elements for these, is it necessary to know something about the general conditions there, so in the paper we will make a short statement of these.

Then we want to show some examples of prefabricated components which already exist and have been used in the harbours in Greenland.

We will finish with a short statement of the possibilities of further progress in prefabrication and industrialisation. Because there must be an advantage of developing much more industrialised components for harbour and coastal structures - seen from a world wide point of wiew. It is important to remark that our definition of industrialised components are products made in a factory - like steel sheet piles - and not prefabricated tailor-made components, which are made on site for the special job.

GENERAL ASPECTS

Due to the very hard living conditions in the arctic areas the population is scattered all over the region and only forms small communities. The population mostly makes a living by hunting and fishing and only in the southern parts there are possibilities of sheepbreeding. Argriculture is impossible all over the region.

In the arctic regions as well as in all other undeveloped parts of the world at the moment big efforts are being made to raise the standard of living.

The possibilities of making life easier and more profitable in these parts of the world lie in the exploitation of the riches in the earth like extraction of oil and minerals, and in the improvement by making the fishery more industrialized, as it has been done during the latest years in Greenland.

Both ways of development for the region make a big demand for harbour construction. The first case will cause the building of handling facilities with relativly big capacity, due to the short period of the year in which it is possible to navigate, if not using ships especially equipped as icebreakers. The improvment of the existing fishery, will cause building of facilities in a smaller scale, but such facilities are absolutely needed for further development. By building big handling facilities it would be natural to use the same methods as used in other parts of the world only taking into consideration the very short construction period each year.

Up to now most harbour works have been planned to a great extent using prefabrication, but mostly by manufacturing the elements in a plant in connection with the harbour site. The use of this method in arctic areas would require a much longer construction period than normal in warmer regions. To reduce the construction period it would be natural to move as much as possible of the works to factories in more industrialized regions so that the procedure on site only would be a pure assembling of prefabricated elements. Prefabrication in this way combined with a really good planning of the constructing procedure would make works in the arctic lesser complicated and lower the costs.

The harbour facilities required for the people living in the small villages are of much lesser magnitude than the harbours already mentioned, but many of the problems are the same.

Due to the short summer the construction period for even small jobs lasts 2 or 3 years. The servicefunctions in the villages are rather bad. The workers available are still not developed enough to make complicated crafts. The materials all have to be transported from other parts except for the aggreates for the concrete. All those points invite the use of prefabricated elements from industrialized countries, because the transport is more or less the same whether the elements are made in Denmark or going to be made on site, the need for imported skilled workers on site is much lesser and the construction period shorter. The jobs can be made in one summer.

But the problem is that those small jobs are not big enough to support the costs of planning and manufacturing of new prefabricated elements for each job, it would therefore under those circumstances be advantageous if some factories took up the development of elements for sorts of harbour structures. Furthermore this kind of (if there were such) elements could of course also be used in other harbour structures in the rest of the world and the production would be more profitable. This evolution would be the same as we have seen in the building industry in the last years, but harbouring would require more cooperation between the countries with only specialized factories in few places because the need for construction of harbours in each country is much lesser than for instance construction of buildings.

A problem with prefabricated constructions is always the joining of the elements and the fixing in the seabed. Under arctic conditions this problem however is even bigger due to the iceproblems which can occur and because of the very often occuring lack of soft sediments overlying the rock, so that it is difficult to fix the structures in the bottom. All those problems have to be taken into account, but it is possible to solve them. In the other papers we will find solutions for this.

2 EXAMPLES OF PREFABRICATED COMPONENTS IN HARBOURS IN GREENLAND

The following examples are from the harbours in Greenland. They are taken from different projekts designed by the different consulting engineering firms working for the Technical Organisation of Greenland, GTO, under the Ministry of Greenland.

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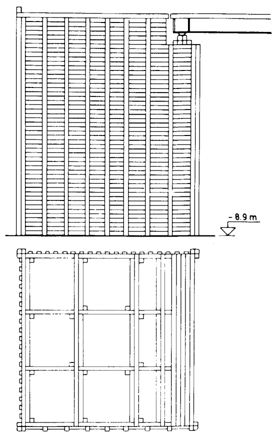

PREFAB: Timber caisson
(WHARF FOR GENERAL CARGO JULIANEHÅB GREENLAND)

Fig. 1.

As mentioned above one of the main problems in harbourconstruction in Greenland is the fixing of the structures in the bottom. An obvious solution for this is just to place a caisson on the bottom. Here has a timber structure been used, because the transport and preparation of timber are easy.

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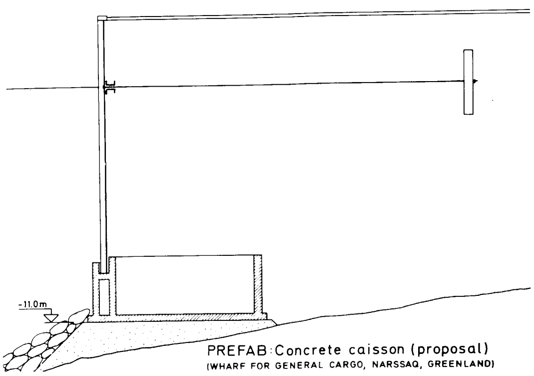

PREFAB: Concrete caisson (proposal)
(WHARF FOR GENERAL CARGO, NARSSAQ, GREENLAND)

Fig. 2.

Another solution is to combine a normal sheet pile wall and a caisson. This gives a lesser consumption of materials and still solve the fixing problem.

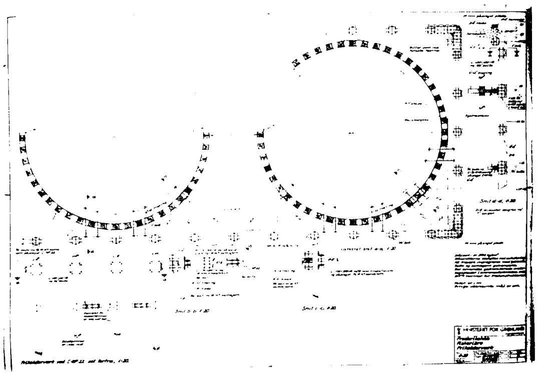

Fig. 3.

To reduce the bending-moments in the caisson-walls are here chosen a cicular caisson.

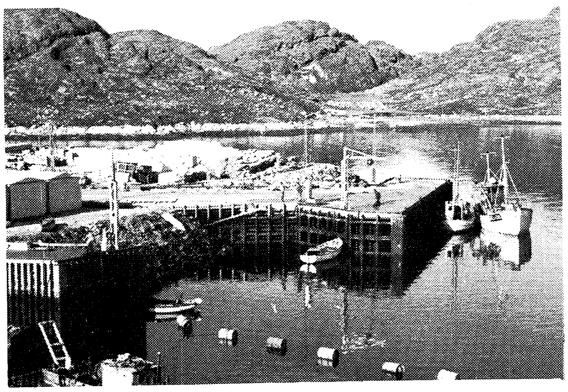

Fig. 4.

Here is the caisson from fig. 3.

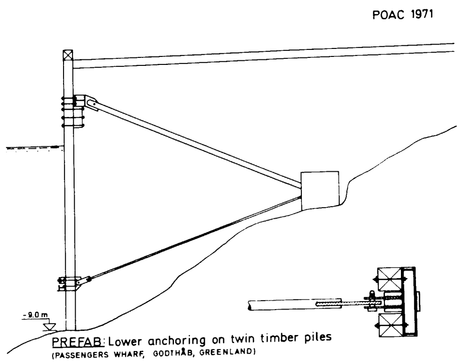

Fig. 5.

Instead of solving the fixing problem by placing a caisson on the bottom, is it possible to make a sheet pile wall with two an-chorings. This solution is good especially where the slope of the underlying rock is sufficient to anchor the bars directly in the rock. This can be done above water at lowwatertime.

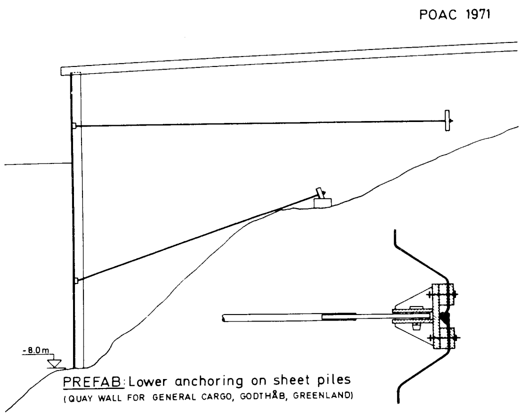

Fig. 6.

At greater quay-height is it necessary to use steel sheet wall and to separate the anchorings.

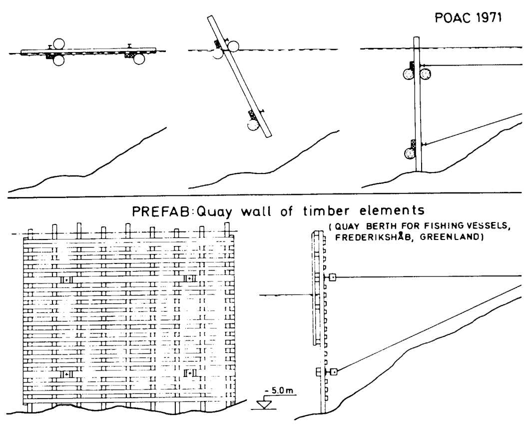

Fig. 7.

Here is a new solution making the timber wall in a big unit on land and then float it out.

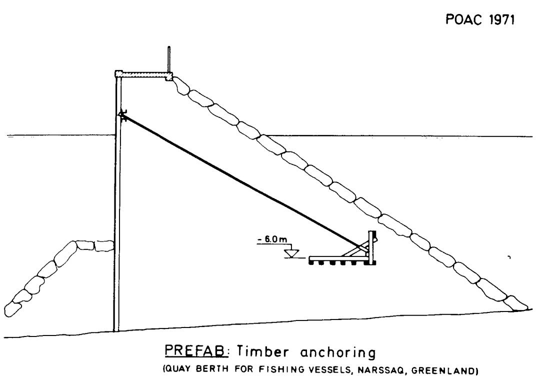

Fig. 8.

To reduce the harbourarea is the inner side of a breakwater utilized as a quay. As fixing for the anchorbars are used a pietab timber construction.

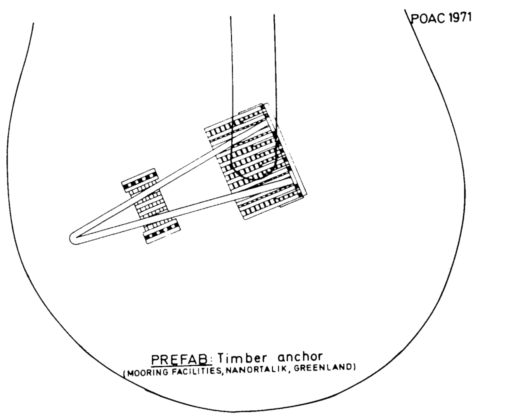

Fig. 9.

As mooring facility is again used a timber structure.

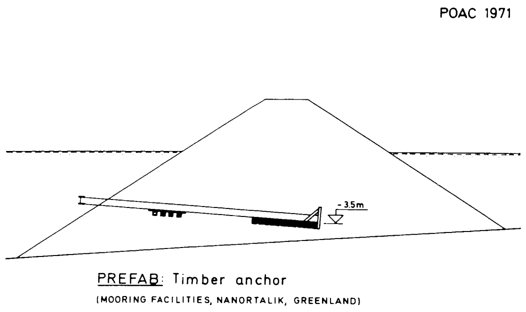

Fig. 10.

Cross-seccion of fig.9.

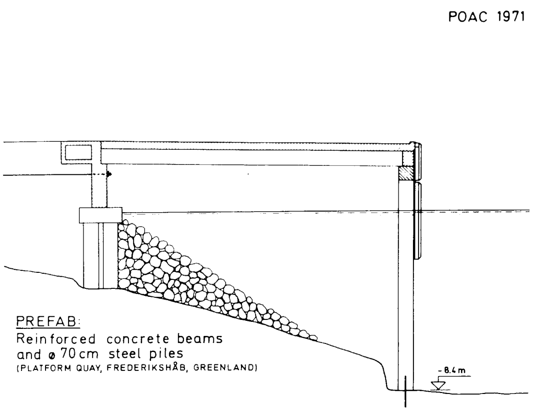

Fig. 11.

To make a greater use of industrialized products is here made a structure where steelpiles are fixed by stainless steelbars in the rockbottom and the superstructure consist of precast prestressed concrete beams.

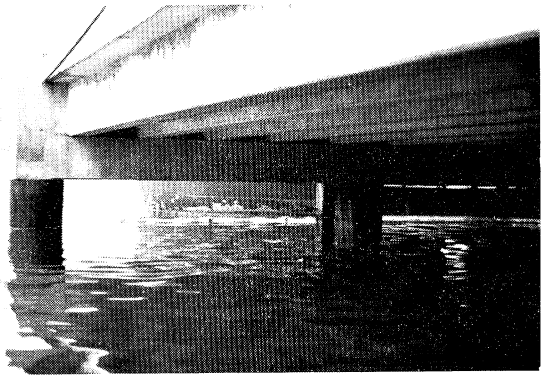

Fig. 12.

A detail from the structure shown in Fig. 11.

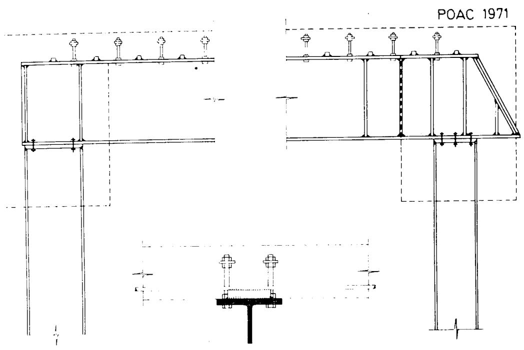

Fig. 13.

Prefabricated steel beams as superstructure supported by prefabricated steel piles.

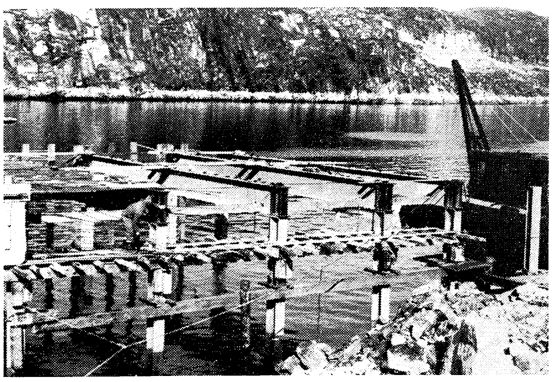

Fig. 14.

A detail from the Structure shown in fig. 13.

POSSIBILITIES OF FURTHER DEVELOPMENT OF PREFABRICATION AND INDUSTRIALISATION

Prefabrication in harbour structures have been used at least in the past hundred years - probably also earlier.

It is obvious that the difficult job below the water surface increases the fantasy do develop structures, which requires minimum of work with divers. In addition to this we have the relentless demands from the nature: wawes, currents, coastal drifts, storms and very often unpleasant conditions in the foundation of the structures. All this leads of course to the largets degree of prefabricated components. And lots and lots of harbours all over the world show brilliant examples upon this - especially in the field of oil-terminals.

But for almost all of the harbours and the different components used we are not faced with real industrialized components, but with prefabricated components tailor-made for the present job. Of course there are exceptions: Steel sheet piles, rubber fenders, bollards and so on! But the main-line is just a prefabrication.

In modern technology it is very wise and necessary if you want maximum of succes to draw parallels to other fields of technology.

For me it is very natural to draw parallels to the remarkable progress within the building industry.

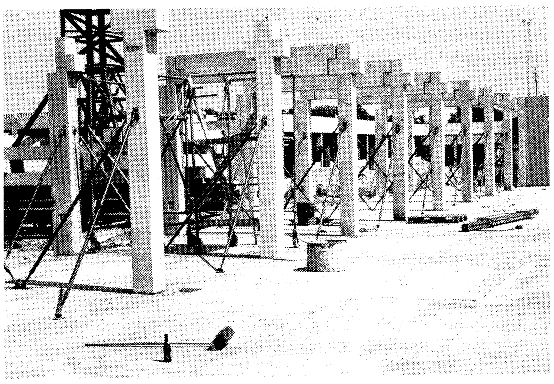

Fig. 15.

Industrialized housebuilding, in this case a school built in a column-beam-system especially developed for schools. (M-system)

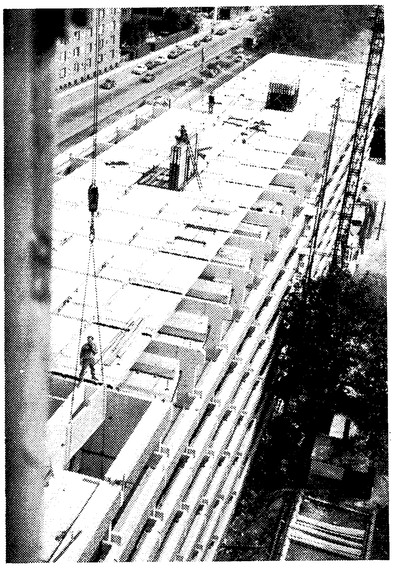

Fig. 16.

Industrialized housebuilding. A hastel built in the TVP-system. A very flexible system consisting of T and V elements forming a frame-system.

Within the building industry - taken in its widest senseindu-strialized methods are at the moment showing themselves successful in many countries. No doubt this development will continue and be accelerated in most parts of the world.

From a technical and economical point of view it will always be an attractive solution to prefabricate elements in a factory and assemble these elements at site requiering a minimum of manpower. In principle prefabrication of houses and buildings has the same conditions as for example the automobileindustry. The technical knowledge is at our disposal, which means, that using it is more or less a question of planning and management.

One of the conditions for this, however, is that the number of jobs, where these prefabricated elements can be applied, is great enough. This, of course, can easily be obtained within housing schemes. An average harbour of 10 Mill. US-dollar equals only 400-500 flats, which is a very little housing-scheme.

The question is, however, to what degree the experiences from the progressive industrialisation of the building industry will influence the harbour engineering in its widest sense.

The expenditure in harbours is a trifle compared with the expenditure in housing. In addition to this comes the fact that the nature creates numerous different problems for the harbour engineer. These problems give only a few indications that standard prefabricated elements are the immediate answer.

In the past, different structural solutions have been developed for pier and wharf structures, but apart from some common principal features there is no conspicuous sign that harbouring will be industrialized to any great extent. And we are all - due to our past experience - able to give numerous arguments why it is so!

Fig. 17.

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"ANALYSIS" FOR FURTHER DEVELOPMENTS OF INDUSTRIAL PRODUCTION OF COMPONENTS IN HARBOUR AND COASTAL ENGINEERING:

MATERIALS	INDUSTRIAL COMPONENTS		
STEEL	?	?	?
CONCRETE	?	?	?
WOOD	?	?	?
PLAST	?	?	?
RUBBER	?	?	?

STRUCTURES	INDUSTRIAL COMPONENTS		
OIL TERMINALS	?	?	?
GENERAL CARGO WHARFS	?	?	?
CONTAINER WHARFS	?	?	?
FISHING HARBOURS	?	?	?
FERRY BERTHS	?	?	?
BULK CARGO WHARFS	?	?	?
MOORING DOLPHINS	?	?	?
MARINAS	?	?	?
DRILLING PLATFORMS	?	?	?
COASTAL DEFENCE WORKS	?	?	?
RIVER CONTROL WORKS	?	?	?
SLUICES	?	?	?
BREAKWATERS	?	?	?
EQUIPMENT	?	?	?

The question to day is whether a rational analysis of the performance of different harbour structures in comparison with the most frequently occuring site conditions could be basis for the development of new structural elements which could be prefabricated and marketed in the same way as for instance steelsheet piles or bollards.

To-day we can notice big industrial firms, which in the past have nothing to do with the building industry, now have realised the big money in producing components of various kind to the industrial housing-schemes. And the big contractors have also realized this and are doing the same thing.

We think it is possible to interest the industry and the big contractors to take up the challenge if we were able and willing to analyse and recommend the most advantageous tracks.

Such a rational analysis is'nt a job for a single consulting engineering firm. It is a job for a commitee which can involve great experience all over the field of harbour and coastal engineering.