AN ANKLE-FOOT ORTHOSIS MADE OF REINFORCED PLASTIC

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1 Abstract

Several groups of physically disabled people need an orthosis to stabilize their ankle-joint. Till now this was manufactured to a large extent of steel. That is why their weight is rather high. By making the right use of the properties of reinforced plastic and by inquiring fundamentally into the functions of such an orthosis, you can get a construction with a lower weight.

Therefore an orthosis has been designed with two shells made of reinforced plastic, connected to each other by (provisional) metallic hinges.

The advantages of this orthosis are:

- very low weight

- better cosmetic design

- the position of the joint that is physiologically wanted can be guaranteed for the whole time it is used, because the orthosis does not deform when it will be loaded.

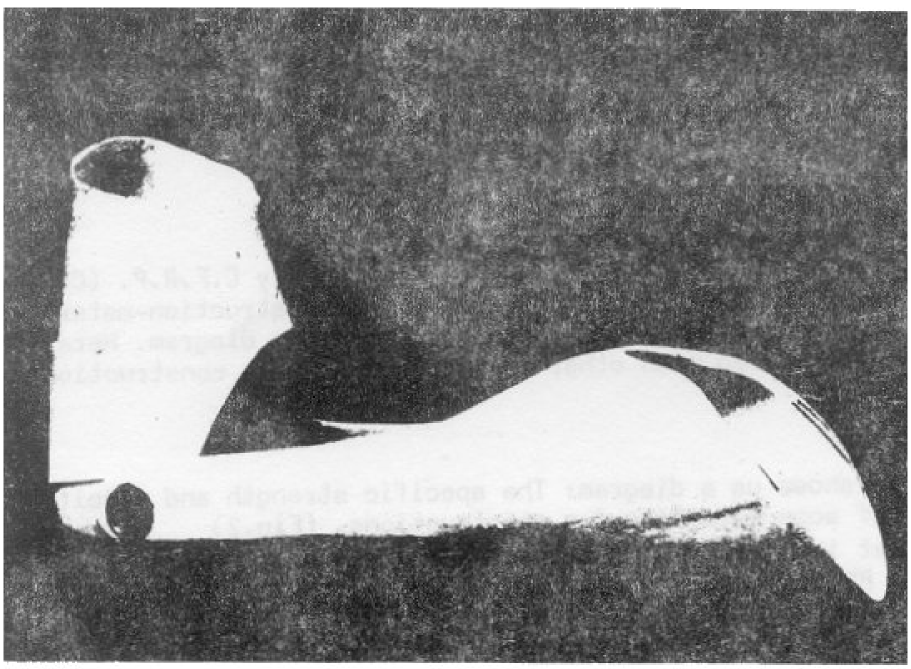

Fig. 1: an ankle-foot orthosis made of prepreg

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Slide 1.

Ladies Gentlemen,

During the next lecture we will throw a light an a few aspects of reinforced plastics and we will mention some possibilities of their application in rehabilitation-techniques.

The research so far has been done in connection with the completing of Mr Klijn's studies at the Technical University of Twente, Enschede, the Netherlands. During this research there was a good and close cooperation between rehabilitation physicians and mechanical engineers.

I will talk about four themes of the reinforced plastics. They are:

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1. The material
2. The choice of this material
3. The possibility of application for rehabilitation
4. Results so far.

1. Material

As a material plastics have a pleasant property when used for constructions. You can give it any shape you want. A big disadvantage of plastics in connection with that in a certain way, is for instance the low level strength and stiffness in comparison with steel. Stiffness is the range of resistance that a certain material or a certain construction offers again deformation. (For materials also called Youngs-modulus). For that reason one has reinforced plastics for certain applications with fibres, uni-directional, woven or spread at random over a surface. At the moment there are a lot of applications of glass-fibres and carbon-fibres. Fibres made of aramid (synthetic fibres too) are in a state of development.

2. The choice **of** the material

G.R.P. (Glass Reinforced Plastic) and especially C.F.R.P. (Carbon Fibre Reinforced Plastic) are very interesting as construction-materials. I hope I can make that clear to you with the following diagram. Here are these materials compared with other (more conventional) construction-materials.

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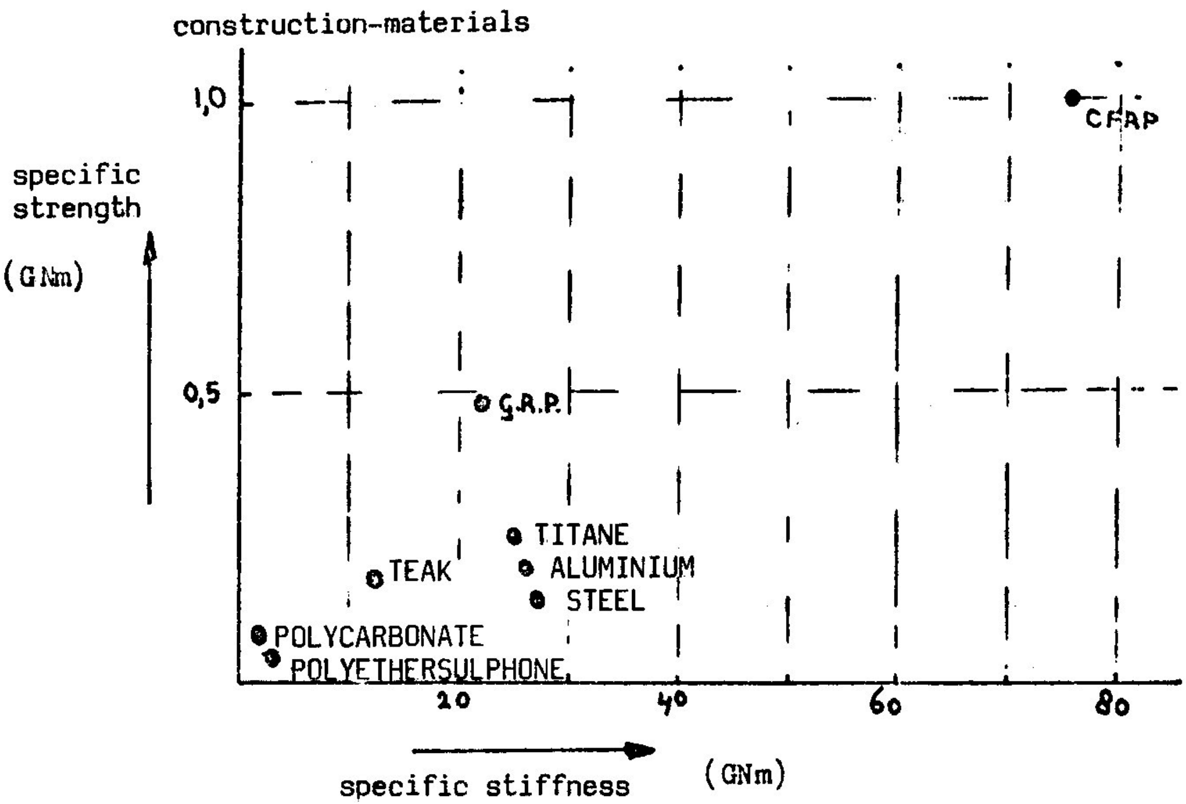
Of the G.R.P. we can say that the specific strength is about twice the specific strength of steel. The specific Younge-modulus is nearly the same of both materials.

The specific strength (five times) and the specific Youngs-modulus (three times) of C.F.R.P. however are superior to for instance steel and aluminium.



CFRP -Carbon Fibre Reinforced Plastic
GRP -Glassfibre Reinforced Plastic

Because the use of prepreg (Pre-Impregnated Product) has a lot of advantages above impregnating fibers by yourself, we chose prepreg for the manufacturing of the prototypes of the ankle-foot orthosis.

For a few reasons glass-prepreg is chosen instead of the superior carbon- prepreg:
1. Glass-prepreg is much cheaper than carbon-prepreg.

2. During this research it was easier to get glass-prepreg.

3. The technologies of working up glass- and carbon-prepreg are not very different.

In a further state of the research one can, if wanted, choose to use the carbon-prepreg.

3. The possibility of application for rehabilitation

Reinforced plastics can be given any form you want before they are cured. But once they are cured they don't deform very much under loading. They can hold their shape very well. Because of those two reasons one can use reinforced plastics very well for equipment that we call the 'body- tied' equipment, such as: - prosthesis

- orthosis

- arch supports.

4. Results

As the subject of research the ankle-fact orthosis is chosen. This choice has been made in the following way:

In England as well as in Sweden people have done research work into the possibilities of application of C.F.R.P. as a material for the construction of orthosis.

With this research work one had big difficulties, especially in getting a good connection between the reinforced plastic and the metallic parts of the orthosis, namely the hinges.

By making as much use of the properties of reinforced plastic as possible and by fundamental analysis of the function of an ankle-foot orthosis,

we tried to get a product with those properties that we wanted it to have. To come to that result a contact was made between the mechanical engineers and the rehabilitation physicians of 'Het Roessingh' Rehabilitation Center, Enschede, the Netherlands.

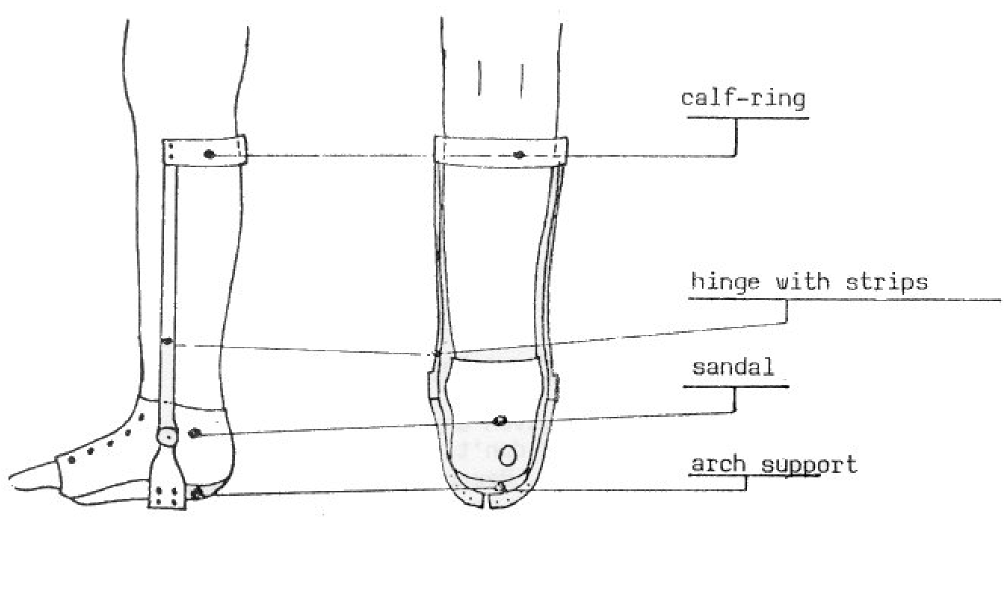
In the conversations which followed that contact it appeared that there

is a need for lightweight orthosis for the following groups of diagnoses:

- spina bifida
- dystrophia musculonum progressiva
- spastic paresis
- poliomyelitis.

To get an application of this orthosis for children was the first part of the research. Because children grow, it is necessary to hold the foot and especially the tarsus physiologically in the right position. Therefore it is not only the lightweight factor that is important, but more than that a good fitting of the orthosis and that it keeps it's shape for a long time. Because of the previous problems with the hinges and the expected pressure on certain places, especially on the tarsus, a patient has been chosen with spastic paresis. In this case you won't get disturbance of the senses.

This has been the starting point of the research.



Slide 4. (Fig.3: conventional orthosis)

A conventional orthosis, made of steel and leather, which had to take care of the stabilization of the ankle-joint of a patient with a hemi- paresis, a buy of ten years old. He had an equino varus position of the foot.

The functions of those orthoses are:

1. To check the equino varus position of the foot

2. To guarantee a position of the foot and the tarsus that is physiologically as normal as possible for a long time.

The orthosis, designed and manufactured during this research, are composed with the aid of a plaster mould of the foot and the leg of the patient. It is very important that the plaster mould is an exact copy of the foot and leg in a physiologically normal position.

Slide 5. (Fig.1)

Here you can see a picture of the ankle-foot orthosis made of reinforced plastic. Or rather: made of prepreg

-The form of the wanted orthosis is roughly laminated an the plaster mould.

-After the resin is cured the wanted form is sawned out.

-The foot shell and the leg shell are connected with each other by means of metallic hinges. The hinges are glued on to the shells with reinforced plastic.

<u>The explication of the form</u>

The leg shell is composed of a ring that is around the leg in such a way, that some motion is possible, and it has two strips which connect the ring with the foot shell and the hinges.

The foot shell surrounds the foot as much as possible. Especially the tarsus and the middle-foot. This foot shell is responsible for checking the rotation of the foot around the subtalair axis.

The only function of the leg shell is to check the plantar flexion in cooperation with the stops at the back-side of the hinges.

The only difference of this type with the next one shown is the stiff bridge of this one over the dorsal side of the foot. The other one has a soft connection in that place.

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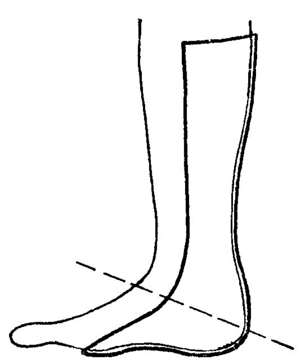
Both types of plastic orthosis have their advantages and disadvantages. Further research into the possibility of application of these orthosis is desirable. Which patient benefits most from type depends on the kind and the seriousness of the affection of illness.

Another example of the possibility of applying reinforced plastic in rehabilitation is the shell at the back of the leg and the foot shown in the next picture.

Slide 7 (Fig.4)



Because the orthosis is made without hinges, the manufacturing is easier than of the orthosis shown before. This orthosis is made for a patient who cannot use his muscles beneath his knees.
Because of this, an arthrodesis of the ankle-joint is needed and no hinges are necessary. Here too the shape kept well and the fitting of the shell.

Finally I will give you an impression of the possibility of decreasing the weight of an orthosis by using reinforced plastic. The conventional orthosis made of steel and leather, has a weight of 0,80 kilograms. The weight of the new orthosis however is 0,35 kilograms. And this specimen is only a prototype.
A further optimisation of the material and the construction can contribute to a further decrease of the weight of the orthoses.
For the material one can think of using C.F.R.P. in those places where the stress on the orthosis is heaviest.
For the construction, one can replace the metal hinges by hinges made of reinforced plastic.
However, the most important advantage of using reinforced plastic for the construction of orthoses is: The position of a joint that is physiologically wanted can be guaranteed for a very long time. This material can hardly be almost deformed!

Thank you for your attention!