SESSION IV
Paper (b)

IMPACT OF THE TERRAIN ON HUMAN EFFORT IN FOREST OPERATIONS

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INTRODUCTION

Even if the work in itself is heavy during manual work operations in logging, environmental factors may contribute to increase of the work load. The factors that first and foremost cause such an increase are climate and terrain.

In Norway we have specially been concerned with the impact on the work load by the terrain. There are various terrain factors that contribute to increased human effort during forest operations. The terrain surface may be littered by obstacles that hinder the freedom of movement. The same effect may be caused by soft and swampy ground and most of all, slope may hamper the forest worker's ability to move around by the need to surmount gravity when he moves upwards.

At the Norwegian Forest Research Institute we have been involved in a project on forest operations in steep forest terrain, and in this connection we have carried out various studies on work load during forestry work in steep terrain. I will give a short review of some of these studies.

GENERAL REMARKS ON STEEP TERRAIN

During the project, the main task has been to develop equipment specially suited for the steep terrain. Steep terrain in this connection is considered forest areas with a gradient steeper than 33% (Ref. 1). In Norway we have around 930,000 ha with such terrain. Mature stands represent 47% of the total volume on these areas or 43,9 mill.cu.m.

Approximately 20% of the steep terrain also has a terrain surface with boulders and screes, cliffs and clefts. This makes it difficult and expensive to construct roads, and cable systems have become the most realistic operational equipment in many areas (Ref. 2).

In this situation the lack of roads leads to a high portion of manual work, even if the systems used are technically sophisticated. It has been of great importance to design the system around the equipment in such a way that the physical work load is reduced as much as possible. In our efforts to obtain this goal, studies of work load have made an important part.

IMPLEMENTATION OF THE STUDIES

The studies were carried out during whole working days, and con-

sisted of telemetric recording of the heart rate each minute during the working day. Work sampling was done with constant intervals (15 sec.) between the recordings, and the work output - usually in cu.m. per hour, was recorded.

Each worker was his own control, and this means that he worked for one day in ordinary terrain and for one day in steep terrain.

To be able to compare the results from various workers, we tried to get a recording of the aerobic work capacity of each worker on the bicycle ergometer. Unfortunately, we did not obtain such information from all the workers that took part in the studies. The comparison between workers was made through computation of mean load during the work time as a percentage of the aerobic work capacity.

CUTTING

We made studies of cutting to tree lengths in even terrain and in very steep terrain (Ref. 3). It was interesting that we found a rather small difference in work load when the work was performed in very steep terrain compared to ordinary forest terrain. In the ordinary terrain the worker used 27% of his aerobic working capacity and only 29.5% in the steep terrain. This is actually the same work load. However, the work output decreased from 3.6 cu.m. per hour of the work time to 1.4 cu.m. per hour when the work was performed on steep terrain. This is a reduction of 62%.

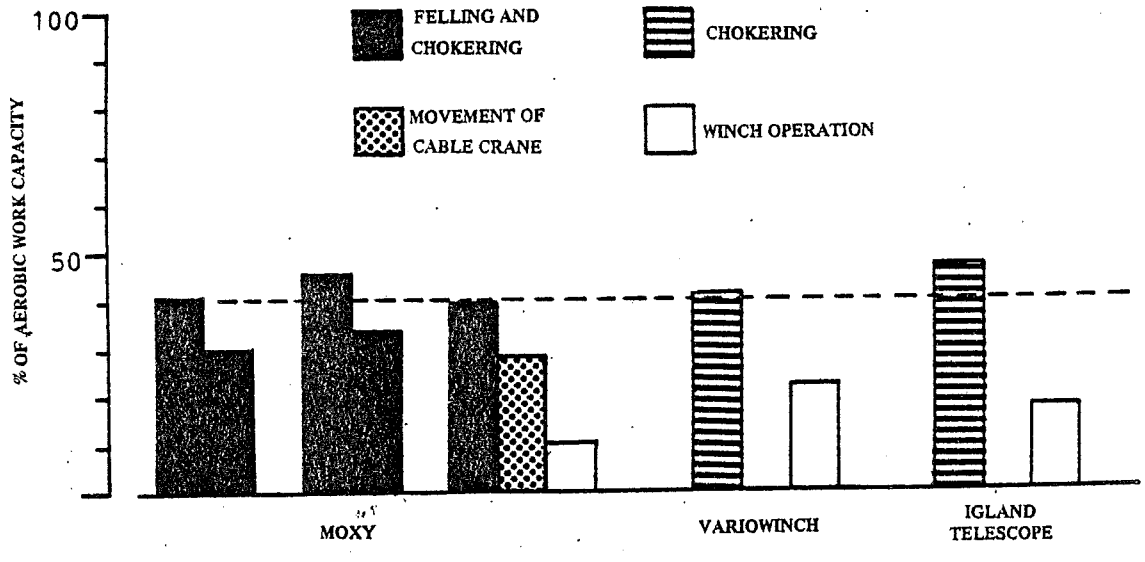

Fig. 1 - Effort during various work operations: The effort is described by the part of the aerobic work capacity that is utilised during the work place time. Each column represents one worker during one working day.

OPERATION OF CABLE SYSTEMS

Most of the studies have been carried out in connection with testing of prototypes of cable systems (Ref. 4).

From Fig.1 it can be seen that the most heavy work operations were "chokering" and "chokering and felling". The chokering operation consist of rather heavy suboperations, but they are interrupted by waiting for the carriage after the next load has been made ready. However, the load during the effective chokering is so high that the mean load in per cent of the aerobic work capacity exceeds the 40% level.

Felling and chokering has been combined in the case of a large interlock cable crane (The Moxy crane). In this case three fallers were part of the crew, and the total waiting time was approximately 30% of the effective time. Also, in these cases the 40% limit was exceeded by only one of the five cases.

RIGGING AND SIDEWAYS MOVEMENT OF CABLE SYSTEMS

In recent development of cable systems in Norway, great importance has been attached to the rigging and methods for sideways movement of the systems to the next logging strip.

In connection with a system that was very popular earlier, we made a study of the work load of a crew during the rigging work (Ref. 5). Earlier many suboperations were very heavy because much of the equipment had to be carried out into the forest. Even if special back frames were constructed for this work, it was still very heavy. The reason for this was the need to carry the equipment upwards, and it turned out that this walking might increase the work load up to 75% compared to the mean load during all walking.

Also, work that was performed above the ground during construction of supports and preparing the spar trees and tail spars, was more heavy than similar work when it was carried out on the ground. Differences in the mean load of up to 30% were found.

In the recent developments the work above the ground has to a large extent been eliminated by the use of a steel spar. Also, the walking has been reduced, and especially the carrying of equipment does not take place as often as earlier.

We have made no studies of rigging with the new cable logging systems, but we have studied the sideways movement of the heaviest system. We found out that the mean load was well below the 40% limit. The reasons for this were partly improvement in work organisation and technical developments and partly the long waiting periods (nearly 50% of the effective time) that were distributed over the working day.

PLANTING

If we are going to exploit the steep forest areas in the future, activities other than logging will take place in these areas. Establishment of new stands is necessary, and we have carried out work studies both on scarification and planting on areas where

cable logging has been finished.

In one case studies of work load was also done (Ref. 6). That was a study of planting, and in this case we carried out studies on the same forest worker both when he was planting in ordinary terrain and in a very steep area. From this study we experienced that the work load was nearly the same both when the work was performed in ordinary and in steep terrain. However, the work output was nearly doubled when the work was performed in ordinary terrain. In a field with 135% slope and boulders and scree, 111 plants were planted per working hour, compared to 258 plants per working hour in the ordinary terrain.

DISCUSSION

It may seem rather strange that very small differences in work load are found when some type of work is performed both in steep and in ordinary terrain. The common idea is that work is more heavy in steep terrain than in flat terrain. This is also often the case when exactly the same amount of work is carried out during the same time in steep and flat terrain.

However, all manual activities during forestry work are more or less heavy. If a work operation in itself is so heavy that we utilise more than 40% of the aerobic work capacity, we have to compensate for the increase in work load when the same work is done in steep terrain in one way or another. The most convenient way to do this is through reduction of work pace.

It has been suggested by Professor Nils Lundgren in Sweden (Ref. 7), that each person adapts to heavy manual work in such a way that he avoids to utilise more than a certain amount of this aerobic work capacity. This part is usually between 40 and 50%. The way of avoiding this extra load may vary. In the planting studies it was observed that the forest worker organised his work in such a way that he for most of the time was moving parallel to the contour lines, and through this avoided the strenuous work of negotiating the gravity forces.

All the studies we have carried through are in accordance with Professor Lundgren's theory. This means that when work becomes so heavy that the "natural effort limit" is exceeded, work output will be reduced, or the strain on the body will be so high that the internal equilibrium of the body processes will be upset. This in due time will cause fatigue or in severe cases, exhaustion. The introduction of rest pauses can counteract the undesirable effects, but this of course will also reduce the work output.

Increase in work output cannot be achieved through increase in human effort - in any case, not in the short term. For young and highly motivated workers, there is of course the possibility of systematic training to improve to some extent the aerobic capacity, but perhaps a better approach would be through training to increase the part of the aerobic work capacity that can be endured during the whole days work. For the forest manager the wisest attitude towards problems of this type would be to try and find organisational measures that decrease the effort during work in steep terrain, so that the work output may be kept as high as practical.

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