Moving and Erecting the Menhirs

By A. Thom

Much has been written about standing stones but no-one seems to have tackled the problems associated with the stresses induced when handling the large menhirs.

We do not know how megalithic people erected the menhirs. For the smaller and medium sizes we can guess and we can show our suggestion is theoretically possible, but for the larger menhirs like that at Kerloas we just cannot even guess. Our calculations of the stresses and forces just do not show possible values. Accordingly we give the method of calculation so that anyone else can try.

Moving

Let us take it that the menhir is lying flat on the ground (we can ignore the idea that the stones were transported by men pulling on ropes). If we can move one end of the menhir to the side (its side) by a small amount, then we can go to the other end and move it. By doing this time after time the stone moves at right angles to its length and so can be transported.

The stone is shown on the left of figure 1. Here the end E of the wooden lever EFG is under the end of the stone. The lever EFG rests on the fulcrum F which we assume to be a large log lying on the ground. By pressing down at G the stone end is raised, but we must estimate if the lever is strong enough. We take it to be of rectangular cross section b ft wide and d ft deep (fig. 2). The vertical force P from the stone may be greater at one end of the stone than half the weight. The greatest bending moment (M) on the lever is $P \times l$, where l is the length projecting beyond the fulcrum F.

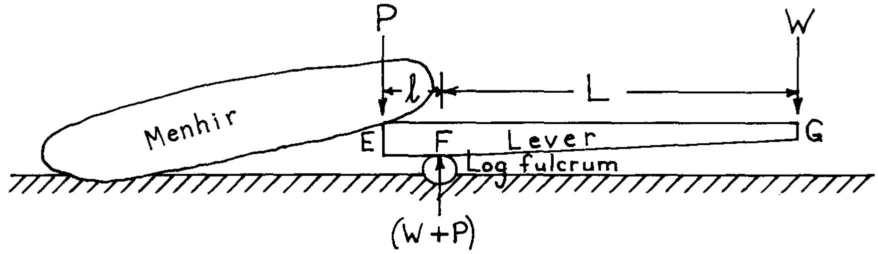

Fig. 1
Side view of menhir, lever EFG and log fulcrum

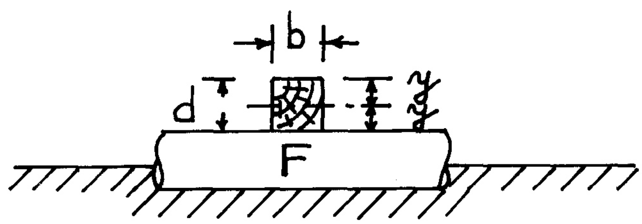

Fig. 2
Section of lever at F on log fulcrum

What is called the 'moment of inertia' or 'the second moment of area' of a $b \times d$ rectangle is $I = b\,d^3/12$. The extreme fibre stress (tension at the top edge) is My/I where y = distance of extreme fibre from the neutral axis, and the timber must be capable of withstanding this.

Now let us apply the above to a typical Stonehenge menhir, 17 ft long by 7.5 ft by 4.1 ft, total volume 523 ft^3. Assume that the material weighs 2.8 times water and so the total weight is 41 tons.

Assume that the heavier end of the menhir is 0.6 of the total weight, that is to say 0.6×41 or 25 tons. The fulcrum might consist of a large log placed at right angles to the axis of the stone. Then if the lever is of square section 1 ft $\times$ 1 ft, $I = 1/12\ ft^4$ and projects $l = 2$ ft beyond the fulcrum, the bending moment is 50 ft tons. The extreme fibre stress (My/I) is $50 \times 1/2 \div 1/12$ which is 300 tons per ft^2 or over 2 tons per in^2. If this is thought to be too heavy a stress for, say, pine, the lever must have a shorter overhang or else two levers must be used simultaneously. The downforce at the outer end W of the lever was probably produced by men hanging on at G. Taking L = 50 ft, it would have needed about a ton of men, that is about 15 men altogether.

Having raised the end of the stone from the ground, it had to be moved sideways — that is to say, the men pulling down at G had to pull sideways at the same time as carrying the load.

Let us try to think of all this happening, getting the fulcrum into position and getting the lever to where it can be moved. (The lever itself must have weighted about a ton). We have taken a simple comparatively light example but what about the huge stone at Kerloas or that at Dol? These are both upright today. How were the levers arranged for these stones and, the greatest puzzle of all, how was the Grand Menhir Brisé erected? How was it transported? It has been estimated that it weighed over 300 tons and of this by far the greater part must have been at the bottom.

As far as we know none of the stones are cut off square at the bottom. It follows that the levers had to radiate more or less from the centre of curvature (in plan). How then was the stone moved sideways or any other way for that matter? We just do not know. We have given the necessary formulae so that anyone can try out any suggested methods.

Perhaps some of these long menhirs were transported by rolling them. The details would have to be worked out for each individual stone and would depend on the weight and the shape. Perhaps in some cases it might have been necessary to cover the ground with long logs laid in the direction of transport. The same type of calculation as we have already given would be necessary were any suggested scheme to be tried out at present.

Erection

We do not know how the large menhirs were erected. The best guess we can make is that a mound was used. Having got the stone into position lying flat, one end was raised a few inches and soil was packed in below; the other end was treated similarly and then the stone lowered to consolidate this ground. This process was repeated over and over until the stone was high enough above the ground. We know from our careful survey of Stonehenge that the stones were ultimately placed within an inch of the required positions. Bear in mind that the tops of the stones are all on one level and that once the stone had been slid into the hole it could not be raised. It might be lowered slightly but *it could not be raised.* The accuracy with which the whole process was completed is inconceivable. For stones like Kerloas and Dol the exact position was probably less accurately required but remember we do not know how these very large stones were lifted, let alone erected.

We have assumed above that the greatest rectangular log which was available was 1 ft × 1 ft. Putting two of these side by side of course reduces the stress but to put them one on top of the other makes an enormous difference provided we have aranged for some means of strengthening the joint between them to take the shear, that is we must insure that the one log cannot slide over the other at any point. We do not consider this possibility because we do not know how the shear was prevented.

Note that the stone must have been brought into the correct position before the hole was dug, that is unless the log fulcrum was strong enough to span the hole.

No matter what the detailed arrangements were, the forces to move the stone must have been provided by men. I think we can forget about the possibility of using animals. Men were also needed for felling the trees, and shaping them and hauling them into position. As in today's projects the designing of the monuments would have been done by a few specialists. These were presumably the same people who carved the geometrical designs on the spherical shaped artefacts and chipped out the cup and ring marks. But the heavy work needed so many men that the ordinary people must have been called in. How were they persuaded to work for the supervisor? Was fear the driving force? Fear of what? Fear of starvation, fear of God or fear of the lash? This is a very real question and is quite independant of any discussion about the possible use of the monuments. How were all these people fed, clothed and housed? Presumably they grew crops and so needed a calendar and this was provided by the stones themselves.

The above notes bring out the enormity of the task that faced megalithic man every time he proceeded to transport and erect one of the large menhirs.

We can well call these people engineers. It is hoped that another modern engineer will bring himself to think about how he would tackle the problem of transporting and erecting one of the large menhirs, using only the materials available to megalithic man.

Resumé of Formula

M = bending moment
For a simple cantilever $M = Pl$ where l = overhang of load P

I = moment of inertia
For a rectangular cross section b wide and d deep $I = bd^3/12$
For a circular cross section with diameter d, $I = \pi d^4/64$

p = extreme fibre stress $p = My/I$ where y = distance from neutral axis to extreme fibre
p should not exceed say 3000 to 5000 lb/in²