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**A Manual Beaming Device: An Improved Method for Warp  
Winding in Broadloom Weaving**

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**Abstract**

Challenges with broadloom beaming that affect the weaving process and eventually the woven fabric aspect, could be as a result of the great bulk of yarns attached to the weighted box for tensioning. This project sought to construct a beaming device that maintains even tension of warp yarn at beaming by reducing the amount of yarns held together in a group to the weighted box. The study employed the Universal Research Methodology (URM). Results from interviews and observations, aided in constructing an appropriate device for beaming. In the study, relevant data was solicited from textile students and technicians at the textile section of the Industrial Art Department of

Kwame Nkrumah University of Science and Technology which aided in designing the blueprints. The outcome of the study after 14 beaming revealed that challenges and faults hitherto encountered at beaming and weaving were largely absent. The study recommends the adaptation of this new mechanism and method of warp attachment to ensure smoother weaving and enhanced fabric quality.

**Key words:** Broadloom Weaving, Warp Preparation, Manual Beaming, Beaming Device, Tension Differentials

### Introduction

The problem of tension differential across the warp during weaving has been studied in both factory scale weaving and manual craft-based weaving. In factory scale weaving, the threads making up the warp are drawn through tension disks before they are wound onto wrapper's beam together with other threads (Lord & Mohammed, 2010). Tension can therefore be set uniformly by ensuring that the appropriate loading is equally applied to all yarns. Any incorrect application of load on a yarn leads to a tension differential that affects weaving and the eventual fabric aspect. Whereas the process has undergone significant development because of the need to maintain precision and quality under factory conditions, the same cannot be said for beaming for craft weaving. Equipment and processes are substantially different and in most cases, do not guarantee comparable high-level outcome as in factory beaming.

This notwithstanding, certain measures are taken to improve the outcome. The use of paper chips and collars in-between warp layers and edges can help even out tension differentials and entanglements that may occur during weaving. This in addition to the application of extra tensioning during beaming produces a very smooth and solid beam package (Peggy, 2011). Other methods have consisted in the use of tension boxes comprising essentially pegs over and under which narrow bands of warp pass, are used in section beaming to equalize tension (Sandra, 2015).

In a process carried out to wind threads in open width directly to the warp beam (Kerstin, 2011) a warping valet (trapeze) was used to even out tension in the warp and also eliminated the need for helpers. The warp threads were stretched from the beam, through the reed, over the breast beam, under the foot rest, up over the valet (which essentially is a cross bar with posts erected diagonally from the loom to hold it) and down to the floor. A weight in the form of bricks provides the needed loading for tensioning. Broader warps can be divided into sections before weights are attached to each. Additional measures to ensure even tension consist brushing of threads to further straighten them (Tien, 2009) and in the process also identify loose ends.

In still keeping to getting rid of helpers whose actions could cause tension variations across the warp, small warps can be beamed by one person with the threads held in one hand whilst the other turns the crank to wind it unto the beam. The method however results in tension variations in the warps closets and further away from the crank of the warp beam (Madelyn, 2014). The AVL with its in-built tensioning system cuts out most of the challenges already mentioned (Tien, 2010), but however limited to sectional warping.

The focus of this innovation in broadloom beaming draws from a lot of the positives from methods mentioned earlier. Notable amongst these are:

1. Tensioning the warp in smaller sections instead of in bulkier units.
2. Use of dead weight in place of helpers.

It is worth mentioning, however, that it is not suitable for sectional beaming, but most appropriately useful for wide warps on broadlooms.

### **Methodology**

The Universal research methodology used for this project, employed interview and observation to gather relevant data in the assessment of challenges encountered during broadloom weaving and soliciting ideas for possible interventions at alleviating same. The weaving shed at the textile section of the industrial art department was purposively selected due to convenience and proximity, to basically identify the challenges encountered at beaming using the broadloom. The population of the study was textile students and technicians.

### ***Design Process***

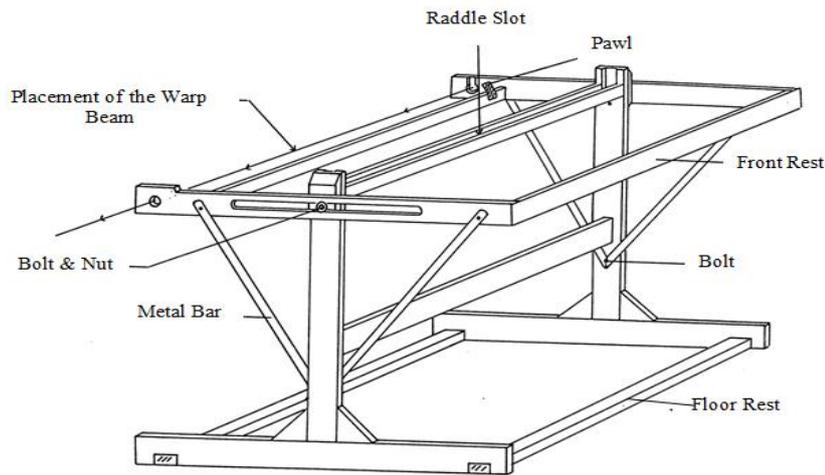
The design development process was carefully undertaken to produce the manual beaming device for warp winding based on the steps outlined in the Universal Design Methodology (UDM). This gave a systematic procedure to ensure effective design of the blueprints and production of the beaming device. It entailed three key phases: the Analytical, Creative and Executive phases.

***The Analytical Phase:*** A survey of the beaming process at the weaving shed of the textiles section was conducted to observe critically the challenges encountered. Even though there are many weaving sheds around, the weaving shed at the textile section was selected based on proximity and convenience. The survey revealed that students used the same broadloom to be used for weaving to beam warp yarns unto the warp beam. This phenomenon created some challenges and faults at beaming due to causes outlined earlier. Dimensions of the broadloom and the warp beam were taken to guide the appropriate design and construction of the beaming device.

***The Creative Phase:*** This stage involved the making of technical blue prints or sketches for the beaming device and weighted box. The best designs were selected with the help of students and technicians, and further developed for the project.

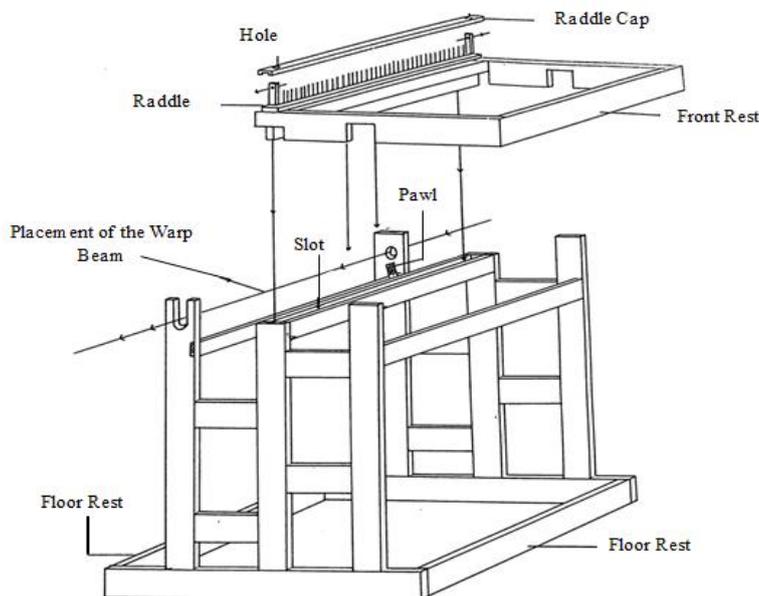
### **The Beaming Device**

As shown in Figure 1 to 4, drawing plans or sketches were made for the beaming device.



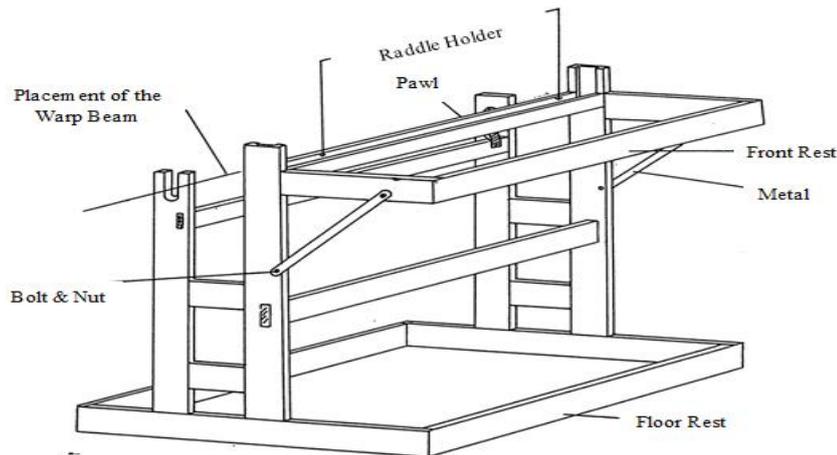
**Fig. 1: Beaming Device 1**

The design as shown in Fig.1 is characterised by a removable top structure which is held to the uprights with a bolt and nut. It is simple in structure consequently requiring less material to construct.



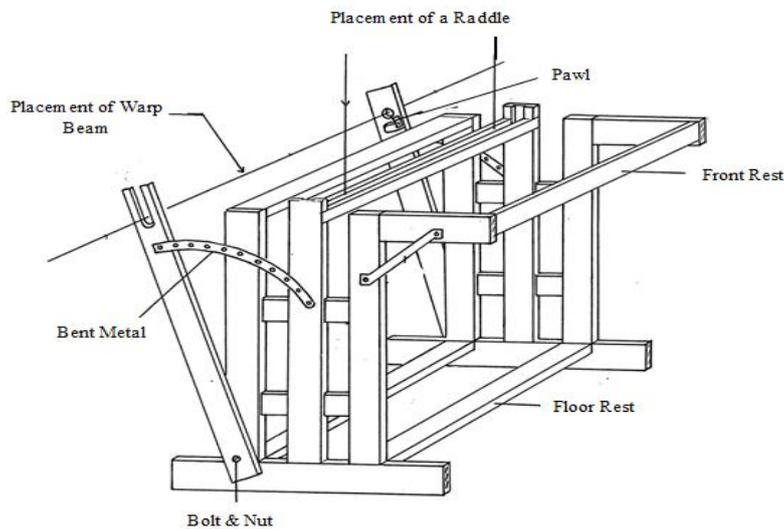
**Fig. 2: Beaming Device 2**

Fig. 2 shows a relatively complex design, thus requiring many materials to construct. It is composed of a removable top structure which fits to the uprights. It however lacks the necessary support at the base of the uprights to ensure firmness.



**Fig. 3: Beaming Device 3**

The front rest of the design shown in Fig. 3 is hinged to the uprights thereby putting pressure on the upright bar. The design is again found to be complex in Fig. 4 making it not only expensive and bulky but difficult to transport. There is also no reinforcement of the base structure to the uprights.



**Fig. 4: Beaming Device 4**

**Evaluation of Design Concepts**

The table below shows the evaluation criteria of the four designs developed.

**Table 1:** Evaluation of Design concepts for the Beaming Device

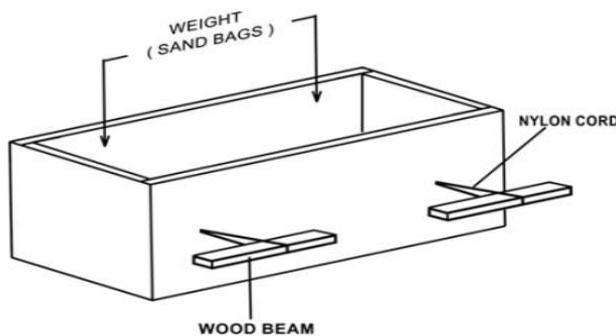
Evaluation	Design One	Design Two	Design Three	Design Four
Structure Design	Simple	Complex	Complex	Complex

<b>Structural Parts</b>	Fewer parts	More parts	More parts	More parts
<b>Easy to Move</b>	Very easy	Not very easy	Not very easy	Not very easy

The four drawing plans for the beaming device were evaluated based on the structural design (appearance), structural parts (the composing wood parts) and the ease with which it can be moved about in the weaving shed. Designs 2, 3 and 4 were seen to be complex in structural appearance due in part, to the composing wood parts thereby limiting ease of movement. Design 1 was however adjudged to be simple in structural appearance due to the fewer parts used in construction and also allowed for easy transport.

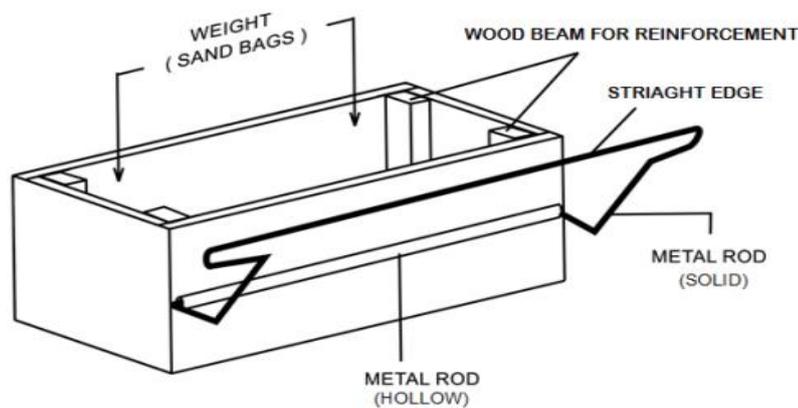
**The Weighted Box**

As shown in Figure 5 and 6, the blueprints for the weighted box were made.



**Fig 5: Weighted Box 1**

Fig.5 is characterised by two wood beams attached to the weighted box by means of nylon cords. This structure only ensures the division of the warp yarns into two large groups, a situation already identified as the prime reason for the lack of even tension across the warp sheet during beaming. The structure was found to lack reinforcement at the four corners inside the box.



**Fig 6: Weighted Box 2**

The design in Fig. 6 composing essentially of a solid metal rod, hollow metal rod and reinforcement at the inner corners of the joints proved to be better. The straight edge of the metal rod allowed smaller groups of warp threads to be tied at equidistance across it, thereby reducing the tension differential on yarns across the warp sheet.

**Evaluation of the Design Concepts (Weighted Box)**

The table below shows the evaluation criteria of the two designs selected.

**Table 2:** Evaluation of Design concepts for the Weighted Box

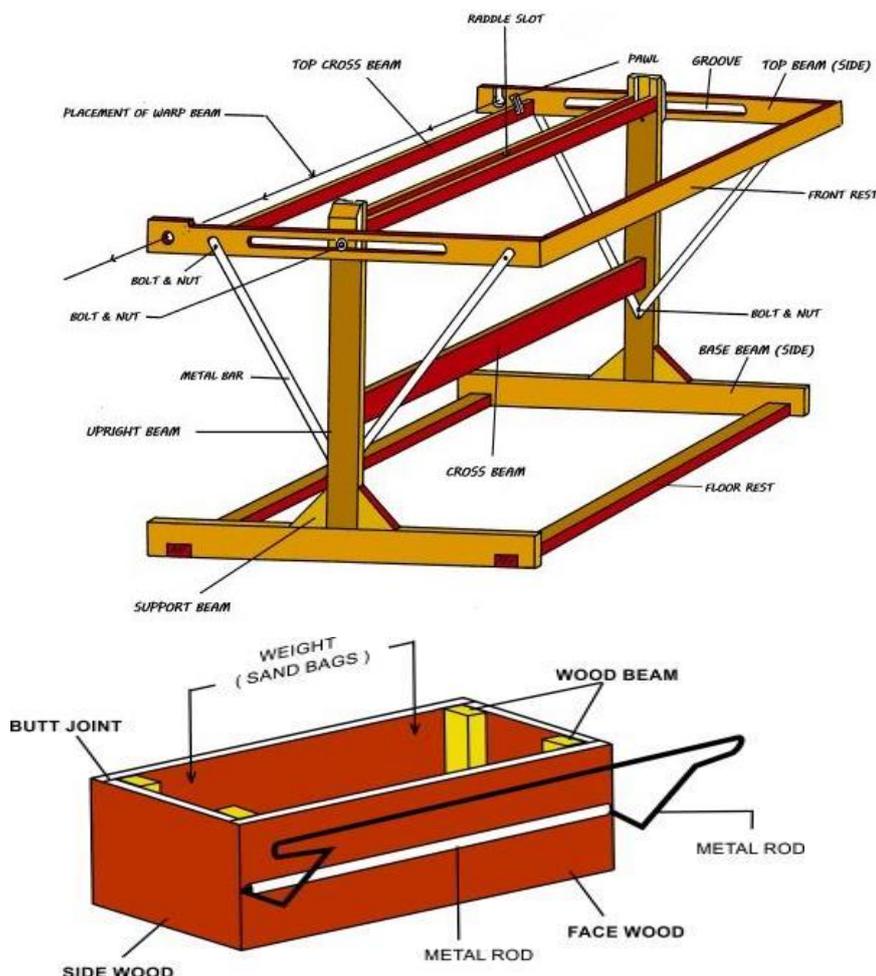
<b>Evaluation</b>	<b>Design One</b>	<b>Design Two</b>
<b>Structure Design</b>	Simple	Simple
<b>Attachment of Warp Ends to the box</b>	To two small wood beams secured with nylon cord	To the straight edge of the metal rod
<b>Joint Reinforcement</b>	No reinforcement	Reinforcement using wood beams

The two drawing plans for the weighted box were evaluated based on the structural design (appearance), attachment of the warp and reinforcement of the joints. Even though the two design concepts were relatively simple in structural appearance, design 2 allows for the attachment of the warp in smaller groups to the weighted box due to the straight edge of its metal rod as compared to that of design 1. The inner corners of the weighted box in design 2 were also reinforced with wood beams to ensure joint strength.

**Selected Design Concepts**

The selected design for the beaming device measured 55"x40"x35½" for length, height and width respectively (Fig. 7). It was selected based on simplicity in structural composition, ease of movement, firmness of the structure and user-friendliness.

The weighted box measuring 30"x13"x9½", was also selected based on the removable and movable (up and down) metal rod which provides a straight, firm edge for attaching yarns in smaller groups. This ensures an appreciable equality in tension of the warp across the full width. A diagram to indicate the vital parts of the beaming device and weighted box are shown in Fig.7.



**Fig. 7: Detailed Labelling of the Beaming Device and Weighted Box**

**The Execution Phase:** This stage essentially involves the construction of the specific parts of the beaming device and the weighted box.

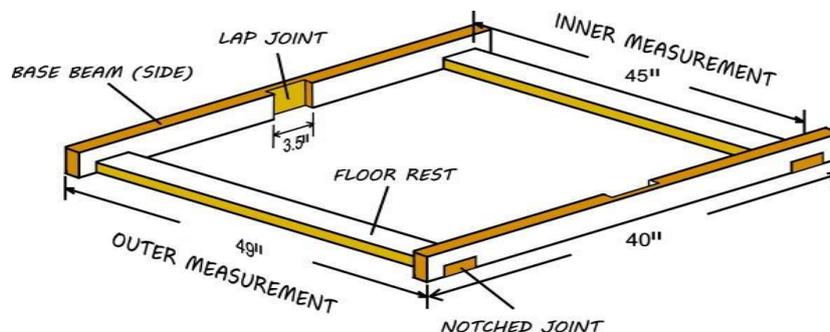
### Construction of the Beaming Device and Weighted Box

Red wood, a known tropical hardwood specie was used in construction of both the beaming device and the weighted device due to its excellent properties of resistance to decay, insects, shrinking and warping. Its durability and performance or wood workability are exceptional. Appropriate joints were used to connect the three essential parts of the beaming device and weighted box.

**Joints Used in the construction:** The appropriate wood joints used in joining the parts for the beaming device were Lap joint, Mortise and Tenon joint, Notched joint and Rabbet joint. The weighted box was made of a butt joint.

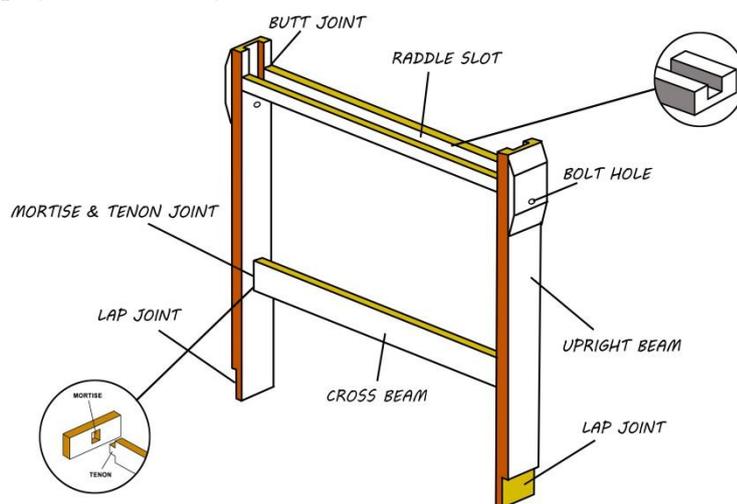
**The Beaming Device:** The beaming device was constructed in three essential parts as mentioned earlier before assemblage.

**The Base Structure:** The base of the beaming device was constructed after the various parts were cut to the right dimensions. It is a rectangular structure which consists of side beams, floor rest and appropriate joints. It has an outer measurement of 49 inches by 40 inches as shown in Fig. 8. The base beam (side) consists of two joints; the lap joint and the notched joint. The lap joint with a width of 3.5 inches was cut in the middle of the side base beam. At the ends of the base beam, a notched joint was cut to the right width of the floor rest. In the joining process, the floor rest was joined to the notched joint using wood glue. This joint was further reinforced using nails.



**Fig. 8: Base Structure**

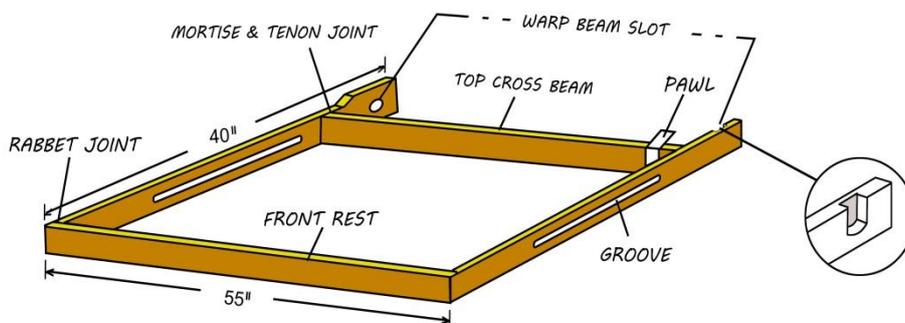
**The Upright Structure:** This consists of upright beams, cross beam, a raddle slot, bolt holes and appropriate joints as shown in Fig. 9. It measures 49 inches (wide) by 32 inches (height). The upright beam consists of three joints; mortise and tenon joint, the butt joint and the lap joint. The lap joint with a height of 3.5 inches was cut at one end of the upright beam to be joined at the centre of the wood beams of the base structure.



**Fig. 9: Upright Structure**

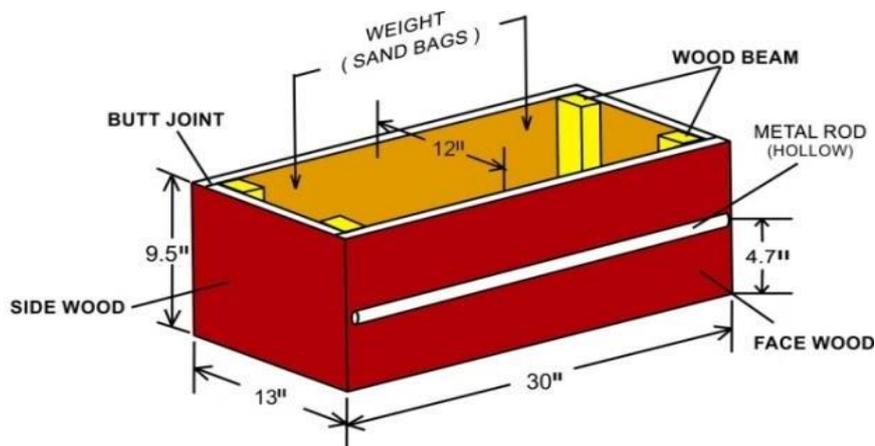
A mortise was created almost at the middle of the upright beam using a chisel. A tenon was cut on the ends of the cross beam which fits exactly into the mortise. At the other end of the upright beam, a small groove was made which fits into the slot cut on the longitudinal side of the raddle beam. This raddle beam was joined to the upright beam using a butt joint.

**The Top Structure:** It consists of the top cross beams, a groove, a pawl, warp beam slot and appropriate joints as shown in Fig. 10. It measures 55 inches by 40 inches. The joints used for the top part were rabbet joint, mortise and tenon joints. At one end of the top beam, a rabbet joint was created to join its similar joint at the ends of the front rest beam. An opening (groove) of 16 inches in length was cut out in the middle of the top beam using a chisel to aid in easy collapse and removal of the top structure. At the other end of the top beam, a slot was created to help in mounting the warp beam. A mortise was created in between the groove and the slot which accommodates a tenon created at the ends of the top cross beam.

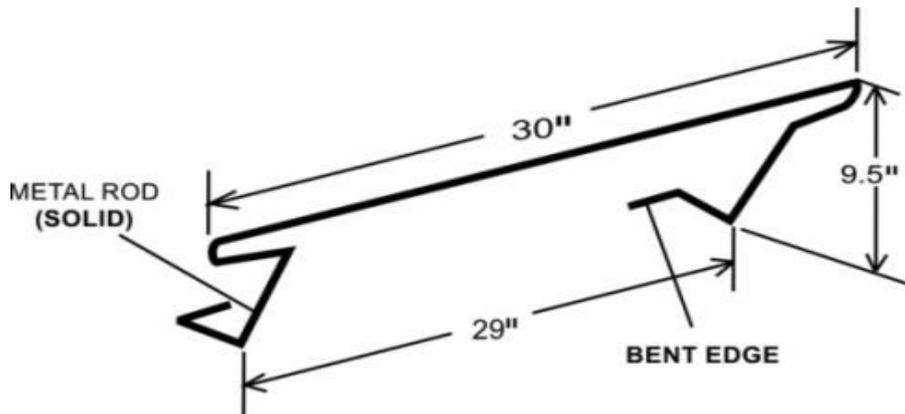


**Fig. 10: Top Structure**

**The Weighted Box:** The weighed box was made to contain sand bags or any appropriate loading. The warp drawn against the weight provides the needed tension for beaming. It has outer measurements of 30 inches by 13 inches with a height of 9.5 inches. It is a rectangular box made from wood beams. The side woods were joined to the face woods using a butt joint at the corners. This joint was strengthened by placing wood beams at the four inner corners of the joint. At mid-height of the front part of the box (Fig.11), a suitably shaped solid metal (Fig.12) was attached to the box.



**Fig 11: The Box**



**Fig 12: The Bent Metal Rod**

**Assemblage:** The parts (top part, upright structure and the base) of the beaming device were assembled as shown in Plate 1, and treated with sanding sealer, to protect the wood and fill the pores, thus hardening the fine ends of the grain so that at sanding, the surface was smoothed. Plate 2 also shows the complete assemblage of the weighted box.



**Plate 1: The Assembled Beaming Device**



**Plate 2: The Assembled Weighted Box**

### Discussion of Results and Findings

The beaming device together with its weighted box was designed and constructed solely for beaming. It is equipped with a riddle and warp beam slot as shown in Plate 3 and a detachable top structure to ease movement. This makes room for removal and placement of different riddle sizes to be used for the process.

Before beaming on the broadloom using the old method, the reed cap and reed are removed to pave way for a riddle that is tied to the race board of the sley (Plate 4) to keep is sturdy, an exercise that is essentially time-consuming. This is however different in the new method since the riddle is housed in a slot created on the cross beam connected to the uprights.



**Plate 3:** Beaming on the Beaming Device



**Plate 4:** Riddle tied to race board

In the study, 14 beamings were carried out at the weaving shed to test the efficiency and effectiveness of the beaming device aimed at resolving the afore-mentioned challenges at beaming and weaving. A comparative assessment was carried out on the beamed warp at beaming and weaving using the broadloom and beaming device.

### Challenges at Beaming using the Broadloom and Beaming Device

It was evident from observation during a survey at the weaving shed that, some students held the warp at a point when beaming on the broadloom as shown in Plate 5 to tension the warp as compared to beaming on the beaming device where the warp is not held at any point. This method of holding the warp does not ensure uniformity in tensioning since there is bound to be a difference in tension between the warp when it was attached to the weighted boxes and when subsequently held by hand and pulled against direction of rolling getting to the end of the process. In fact, the lack of a tensionometer to record tension on the yarns at different times heightens this uncertainty.

This situation was however different when using the beaming device since at no time was it required for the warp to be released from the boxes because the boxes had gotten so close to the loom but still had enough yarn tied in a knot to the boxes. The advantage gained with the new design lies in the fact that warp threads are tied to the rod in such a way as to allow only a small reserve for making the knot thereby making full use of the length of warp.



**Plate 5:** Students holding the warp



**Plate 6:** Warp attached to the beam box



**Plate 7:** Smaller warp groups attached to the new weighted box

The old method of attaching the large bunch of warp threads to the box (Plate 6) led to entanglements that often cause wastage. This phenomenon is eliminated with the use of the new weighted box. The warp is well straightened because it is tied to the metal rod in smaller bunches at beaming (Plate 7) thereby making maximum use of the warp length.



**Plate 8:** The metal rod



**Plate 9:** The metal rod attached to the hollow bar

The metal rod (Plate 8) is specially shaped at the ends to fit easily into the hollow metal bar (Plate 9) firmly attached to the weighted box. This ensures the up and down movement of the metal rod during beaming. This characteristic feature cuts out the holding of the warp towards the end of beaming as attributed to the older method. This ensures some uniformity in tension from the start to the end of the process.

### Challenges at Weaving

Faults created at beaming further affect the smooth operation of the weaving process. This results in fabric faults such as loose fabric, knots, loose warp in the cloth and weft loops (Sibly and Shajidul, 2004). This affirms the philosophy of “garbage in, garbage out”, a situation likely to be avoided if all stages preceding beaming were carried out correctly.

Tension differentials created using the old beaming method inevitably affect the actual weaving and eventually the fabric quality. During weaving, ends that were loosely tensioned sag at portions along the warp, leading to an unclear shed with attendant incorrect thread interlacing. In an attempt to save this disturbing situation, weavers as and when necessary have to help make the shed clearer by lifting shafts carrying the loose ends with the hands.

Another observed intervention by weavers at correcting such problems with loosely tensioned warp, is to deal with the problem on the woven cloth side. Pieces of short wood beams, fabric or yarn are used to adjust the fabric tension (Plate 10) at affected portions in a bit to improve tension on those loose ends. This slows down the weaving process where with a number of beat-ups, the wood beam shifts resulting in frequent adjustments to maintain tension. This phenomenon as observed and reiterated by some weavers affects the packing of the wefts which undoubtedly form a loose portion of the fabric. These sagging ends turn not to lift completely at shedding resulting in undesirable warp floats (Plate 11) that affect the aesthetics and quality of the fabric.



**Plate 10:** Wood beam used to adjust tension



**Plate 11:** Undesirable warp floats

It was further observed at the weaving shed that 10 out of 14 students who used the beamed warp from the beaming device wove their 3 yards semester project in less than a week with the rest completing their work after a week due to other unrelated reasons.

### Conclusion

Benefits to be derived from a well-prepared warp cannot be overemphasized (Johnson & Russel, 2009). It undoubtedly makes smooth the weaving process, thereby ensuring an enjoyable weaving experience as a reward for time spent in designing, preparation of materials and loom prior to weaving. The joy of seeing the fruit of one's creative efforts built up pick by pick unhindered by sudden interruptions generated by faults resulting from beaming challenges is the expectation of many a weaver. However, such utopia in weaving cannot be attained without the proper equipment for the beaming process. This project deals with all uncertainties resulting from the lack of appropriate equipment for broadloom beaming and has significantly improved tension across warp yarns by changing the manner in which the warp is tied to the weighted box. Loosely tensioned warp ends hitherto detected by feeling with the fingers across the warp sheet as a way of assessing the tension profile have been drastically reduced. This has been made possible by reducing yarn deflection with consequent increase in tension at the ends of a large group of warp ends, whilst the elements that run straight maintain a lower tension.

The situation is even aggravated by whatever method is used in attaching the warp to the weighted box. The method recommended for use with this new beaming device is one employed in broadloom weaving for securing warp ends to apron sticks before weaving commences. In fact, smaller sections of the warp sheet are tied to the apron sticks with a knot that can easily be undone allowing for easy adjustments in the warp tension if need be. The wholesale adoption of this method of securing warp yarns to the metal bar attachment of the weighted box contributes significantly to the success accruing from the use of the beaming device. Prompt and precise interventions can be made whenever needed without much encumbrance.

The authors acknowledge the fact that the lack of a yarn tensionometer to assess the tension profile of warp ends leaves much of the judgment to be subjective. This notwithstanding, the effects of its use can easily be adjudged by feel, a method long employed in broadloom weaving for assessing tension profile on warp yarns before and during weaving. Additionally, an enjoyable, smoother weaving process, resulting in a better fabric aspect recorded, is enough proof of the success at dealing with the matter of uneven tension profile across the warp. In light of this, the paper recommends that

students and weavers should adopt this new mechanism and method of warp attachment at beaming. This will reduce the downtime at beaming on the broadloom when attachment would have to be removed to pave way for the process.

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