Global Jour. of Engg. & Tech.
Volume 3, Number 2 (2010) 301-308

DESIGN CONSTRUCTION AND TESTING OF A LIVESTOCK LOADING AND UNLOADING RAMP

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Abstract : Loading and unloading constitute major aspects of livestock transportation. In many circumstances, they are accomplished with a lot of drudgery and harm to both the livestock and handler. More friendly handling methods are desirable. A simple wooden ramp was designed and constructed at the dairy unit of the teaching and research farm of the University of Ibadan. The ramp was tested by loading cattle into a trailer while observing any physical damage and consolidation movement of the columns. The integrity of the structure was maintained while no consolidation movement was observed. Animal exhibited reluctance during loading but unloaded with ease. An extended curved race and screening are desirable in order to derive maximum benefits from the use of the ramp. Tests of longer duration should form the thrust of future work.

Introduction

Livestock and livestock products constitute major sources of food, employment, income and industrial raw materials all over the world. The inadequate supply of these products through natural means such as hunting and gathering motivated the idea of domestication which dates back to about 8,000 BC (Anonymous, 2008a). However, the variability in weather and climatic conditions all over the world restricts the raising of some livestock to certain regions but which are universally demanded. Transportation remains the only means of distribution of such livestock species. Livestock transportation is done for a number of reasons. These include the search for grazing lands especially during drought, movement from the rural areas which are often the centres of production to the urban areas where there are adequate processing facilities and higher demand for the animal products, and establishment of new livestock farms (Iro, 2007). Even within the urban areas, the livestock markets are often far away from where the slaughtering is done, such that, when the livestock have arrived at the urban area, they still have to be re-transported for slaughtering. In Ibadan for example, the distance between the Akinyele market where the cattle transported from the northern part of the country are discharged, is about 19 km from Bodija market where the central abattoir is located. Substantial movement is still involved in getting the cattle from the market to the point of slaughter.

Filani (2005) and Iro (2007) identified three major methods of livestock transportation. These are hooves conveyance, railway carriage and road truckage. Howevej in many developing countries, the majority of livestock for slaughtering are moved by road truckage while the search -for grazing lands is by hooves.

Keywords : Cattle, consolidation movement, guard rails, livestock, ramp

An important aspect of livestock transportation is the loading and unloading of the animals into the transport vehicle. The handling of the animal at these levels has effect on the animal while in transit and after destination. Most injuries and stresses experienced by the animal throughout the transport process between the farm and slaughterhouse are most likely to occur during loading and unloading especially where facilities and handling practices are unsatisfactory. These contribute significantly to poor animal welfare and loss of production (Ademiluyi et al., 2000; Robert, 2002; Anonymous, 2003). In many developing countries such as Nigeria, livestock loading is accomplished by dragging and battering of the animal into the transport vehicle. This often leaves the animal injured even before the commencement of the journey that could last for over 24 hours. Plate–1 shows loading practices at the Bodija market in Ibadan. Nigeria. Livestock could be transported more effectively and with less stress if care is taken during the loading process using simple and effective facilities and 'techniques. The livestock handler will also be more protected against injury (Lapworth, 2007). A simple and effective method through which this could be achieved is to use a ramp.

Plate-1 : Cattle Loading into Transport Vehicle.

Description of a Ramp

A ramp is a facility that allows access between two points at different levels (Encarta Dictionary, 2008) and in livestock transportation, the two levels are the ground on which the animal moves and the vehicle into which it is to be loaded. Depending on the type, a typical livestock loading ramp may comprise of a race, the walking and loading platforms, columns and stringers, and guard rails. Slope and surface roughness are two principal factors that must be considered in the provision of a ramp.

Livestock slippage could be a major cause of injury and hence the surface must be such that prevent the animals from slipping. Observations of many livestock facilities indicate that the number one problem is slippery floors that cause cattle to fall (Lapworth, 2007). Excessively steep ramps should be avoided. The slope should be such that the animal does not fall backward as it is climbing. Various slope values have been recommended by different authors but in general, the slope should be between 12 and 20 degrees, the lower the better (Linden and Halpin ,1994; Lapworth, 2007; Anonymous, 2003; Grandin, 2007).Livestock loading using a ramp could be further enhanced by using curved races and fully covering the sides of the ramp to provide visual barriers.

Ramps could either be stepped, staired, grooved or cleated to aid the smooth movement and ensure that the animals do not fall backward as they climb. Stepped concrete floors have 100 mm rises and 500 mm treads. Cleats on wooden or concrete floors are 300 mm apart at the centres, and about 50 mm high and 50 mm wide. (Lapworth, 2007).

The need to adopt a more friendly approach in livestock loading in Ibadan and environs motivated this work. This paper presents the design, construction and test results of a wooden ramp for the loading of cattle into vans at the University of Ibadan teaching and research farm.

Materials and Methods

(a) Design Considerations :

(i) Ramp Specifications

An effective design of a ramp must take into account the type of animals to be transported and the vehicles into which they are to be loaded. The ramp in this work was to be cleated and constructed from wood.

The popular vehicles used for livestock transportation within Ibadan environs include Pick-up vans, Nissan-lorry and tractor trailers. The floor height of these vehicles varies between 0.85 and 1.2 m above the ground and a height of 1.0 m was selected for the design. Cattle are the main livestock transported and the parameters for cattle were used in the design.

In excessively wide ramps, animals tend to turn around increasing stress, the time taken to load and the risk of injury (Chambers and Grandin, 2001). In order to guide against this, a width of 0.9 m was considered adequate for the ramp. A slope of 15° which is commonly used for non-adjustable ramps was chosen.

Cost availability and simple technology of construction governed the choice of timber as materials of construction. Three timber species Afzelia Africana (Apa), Nauclea diderrichi (Opepe) and Lophira alata (Ekki) which belong to Nl strength group were recommended for use. Corrosion resistant wire nails were recommended for use as connectors (Nigerian Standards Organization, 1973).

(ii) Loads

Dead and live loads were to be sustained by the ramp. The dead load was estimated from the volume of construction materials and the density. The weight of the animal constituted the live load. The weight of the animal is transmitted to the ramp through the hooves and was expressed as the hoof pressure. Hoof pressure could vary significantly, depending on the type and age of the animal, and whether the animal is stationary or walking. Scholefield and Hall (1986) reported the variation of hoof pressure from 130 kPa, for a stationary Friesian cow to 250 kPa, when the cow is walking. Hoof pressures as high as 400 kPa have also been reported (Di et al, 2001). The force exerted on the ground by a cow walking has been estimated to be about 60% of the bodyweight for the fore hoof, and about 40% for the hind hoof (Di et. al, 2001).

In this design, the hoof pressure was calculated assuming that the maximum pressure is developed when the animal is walking. While in motion, the animal simultaneously lifts one fore leg and one hind leg while the other pair supports the body weight. The body weight was therefore assumed to be transmitted onto the ground through two hooves. In the determination of the hoof pressure, a 493 kg cattle was made to walk over a sheet spread on the ground. The area of the hoof mark made on the sheet was measured with a planimeter to be $0.01326m^2$. The pressure was calculated from the equation

$$\text{Hoof Prensure} = \frac{\text{Animal body weight}}{2 \times \text{area of hoof}} = \frac{493 \times 9.81\text{N}}{2 \times 0.01326\text{m}^2} = 0.18\frac{\text{N}}{\text{mm}^3} \qquad (1)$$

Loads could either be uniformly distributed or act as point loads. Although the animal weight was transmitted to the deck through a very small area which acted like a point load, the fact that the animal could step on any part of the walking platform made it necessary to consider it as a uniformly distributed load. This was the justification for considering the live load in this design as uniformly distributed (udl).

(b) Design Calculations

A sketch of the ramp is shown in Figure-1. With a vehicular floor height of 1 m and slope angle of 15°, the length of the walking patform was 3.5 m. The walking platform was made up of boards obtained from planks and laid perpendicular to its length. The boards were to be nailed onto two stringers which were supported by six columns. Calculations were made for the selection of appropriate dimensions for the platform thickness, arid the sizes of stringers and columns.

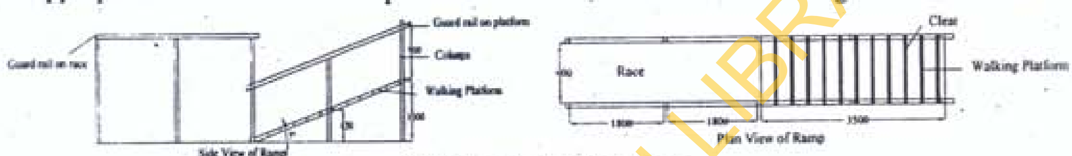

Figure-1 : The Loading Ramp

(i) The Walking Platform

The width of the platform was 0.9 m. A strip of the platform of a width equivalent to the length of cattle hoof (obtained by measurement as 130 mm) shown in figure-2 was tested for bending, shear and deflection to withstand the load imposed as the animal walks over it. The strip is assumed to be under a udl of 0.18N/mm² and built-in at both ends. A suitable thickness for the strip to resist failure by bending was calculated using the following transformed bending stress formula

$$t_b > \sqrt{\frac{w \times l^2}{4 \times \sigma \times b}} \qquad (2)$$

where

t_b = thickness of platform

w = uniformly distributed load (0.18N/mm²)

b = length of cattle hoof (130 mm)

σ = permissible bending stress for grade of timber used (18N/mm²)

l = width of platform (900 mm)

when the appropriate values are substituted into equation 1, the following is obtained

$$t_b > \sqrt{\frac{0.18 \times 900^2}{4 \times 18 \times 130}} = 3.95\text{mm}$$

The maximum shear stress induced on the platform was calculated from the following equation

$$\tau = \frac{3 \times l \times w}{2 \times b \times t_b} \qquad (3)$$

where τ is the shear stress and other symbols are as previously defined.

$$\tau = \frac{3 \times 900 \times 0.18}{2 \times 130 \times 3.95} = 0.48\text{N}/\text{mm}^2$$

The maximum shear stress of 0.48N/mm² is less than the permissible value of 1.8N/mm² for the species and grade of timber selected.

The permissible deflection for wooden beams supporting static load is often limited to 0.003 of the span (Ozelton and Baird, 1976), but when dynamic loads such as walking animals are supported, this is increased by 15%. Shear deflection is also assumed to be 10% of the bending deflection. Taking these assumptions into account, the thickness of the platform required to prevent excessive deflection was calculated from the equation

$$t_d > \left[\frac{1.265 \times w \times l^4}{32 \times E \times b \times \Delta_{max}}\right]^{\frac{1}{3}} \qquad (4)$$

where

t_d = platform thickness to prevent excessive deflection

Δ_{max} = permissible deflection (0.0031 = 0.003 × 900 = 2.7 mm)

when the values are substituted to equation 4, the following was obtained

$$t_d > \left[\frac{1.265 \times 0.18 \times 900^4}{32 \times 11{,}200 \times 130 \times 2.7}\right]^{\frac{1}{3}} = 10.6\text{mm}$$

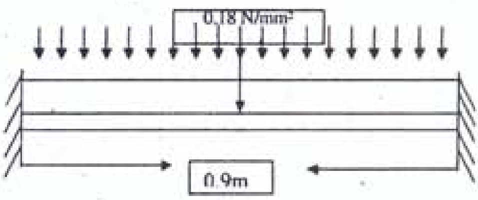

Figure-2 : A section of the walking platform

From the calculations, the maximum thickness required to prevent failure is about 11 mm. However the standard thickness of marketed planks is 25 mm and there is no economic benefit in ordering special sizes. It was recommended that the platform be constructed from 25 mm planks.

The self weight of the walking platform (Wp) is the product of the volume of materials used and the density of the timber selected.

Wp = 0.9m × 3.5m × 0.025m × 864 kg/m³ × 9.81 N/m² = 667.47 N

(ii) Stringers

The ramp was designed to accommodate one cow at a time and the loads to be sustained by the stringers were the sum of the weight of a cow and the dead weight of the walking platform. The load supported by the stringers was computed as follows:

Load sustained by stringers = weight of a cattle + weight of walking platform

4,836.33 + 667.47 = 5,503.80 N

Total length of stringers = 2 × 3500 = 7,000 mm

Load intensity on stringers = 5,503.80 N/7000 mm = 0.79N/mm

Each stringer was to be nailed to three columns and treated as two separate beams built -in at both ends. A typical stringer was designed by considering a span of 1.75 m under a udl of 0.79 N/mm. A trial section of 75 mm x 100 mm was chosen to which equations 2 , 3 and 4 were applied. A bending stress of 0.8N/mm²; a shear stress of 0.28N/mm² and a deflection of 0.28 mm were obtained which were all less than their permissible values of 18N/mm², 1.8N/mm² and 5.25 mm respectively.

The self weight of the stringers was calculated as 2 × 3.5 × 0.1 × 0.075 × 864 × 9.81 = 445N

(c) Columns

Each of the stringers is supported by three columns and the end columns are assumed to carry 75 % of the load sustained by the middle column. The middle columns with unsupported length of 0,45m was used in the design. The load supported by a middle column W_c, was calculated as follows :

Total loads sustained by the six columns is given by = 4,836.33 + 667.47 + 445 = 5,948.80N

$$\text{and } W_c = \frac{5{,}948.80}{5} = 1{,}189.76\text{N}$$

The value 5 instead of 6, was used as the divisor in the calculation of load per column because of the variation in the load sustained between the extreme and middle columns.

Assuming that the column was pinned at both ends, the effective length was taken as being equal to the unsupported length: The design procedure adopted was in accordance with Bengtsson and Whitaker (1986), and the equation is given by :

$$P = k \times \sigma_p \times b \times d \qquad (5)$$

where

k = modification factor dependent on slenderness ratio

b = least lateral dimension of column (chosen as 75 mm)

d = second lateral dimension of column

σ_p = compressive stress perpendicular to grain for the timber selected

With a least lateral dimension of 75 mm, the slenderness ratio was 6 and k = 1; σ_p = 14N/mm^2

$$d > \frac{P}{k \times \sigma_p \times b} = \frac{1{,}189.76}{1 \times 14 \times 75} = 1.13\text{mm}$$

The minimum lateral dimension of the column was already fixed at 75 mm and the second side could not be less. A square size of 75mm × 75mm was recommended.

(c) Construction

An estimate of the sizes and quantities of wood and connectors required were made and procured .from the Bodija Timber market in Ibadan. The components for the various parts of the ramp were pre-fabricated at the timber market and conveyed to the dairy cattle unit of the University of Ibadan teaching and research farm where the structure was erected. The construction exercise was carried out in the following stages

(i) With the aid of tape and wooden pegs, the locations for the columns were identified and marked.

(ii) Holes to a depth of 25 cm where dug and the columns were erected with concrete.

(iii) The stringers were then attached to the columns using 100 mm long wire nails.

(iv) The boards were laid over the stringers and nailed

(v) 50 mm × 50 mm sawn timber was used as beams and columns to construct a 3.6 m length race leading to the walking platform.

(vi) Guard rails from 50 mm × 50 mm sawn wood were attached to the columns.

Plate-2 shows the completed ramp.

Plate-2 : the completed ramp.

(d) Testing

Limited instrumentation made it difficult to measure the deflections on the walking platform.The test observations were therefore limited to consolidation movement of the columns and physically observable damage on the ramp components. The surroundings of the columns were cleaned and scales made on the columns. This was to ascertain any consolidation movement during the test. A trailer was positioned at the higher side of the walking platform. Cattle of live weight between 490 and 500 kg were guided through the race and platform on to the trailer (Plates-3 and 4) and unloaded. After the exercise, the scales on the columns and the various components of the ramp were examined.

Plate-3 : Ramp under test

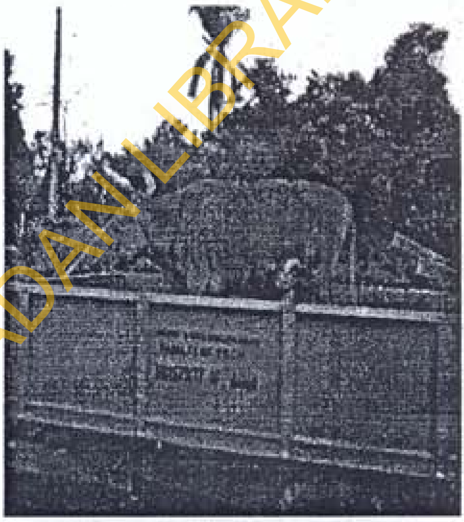

Plate-4 : A cattle loaded in a trailer

Results and Discussion

The cattle used for this test were those kept by the teaching and research farm. On a routine basis, they are taken out of the shed for grazing and returned but are not usually led through a closed path such as the race. When led out of the dairy unit for this test, and upon approaching the race, the animals stopped and were to turn back but had to be forced into the race. The same behaviour was exhibited when they had to ascend the walking platform. The animals however moved along both the race and walking platform once they entered. No difficulty was experienced with the animals during unloading. This is not unexpected as the animals presumed danger ahead during loading. Their fear was heightened when they sighted the trailer at the other end of the ramp. A longer and curved race with side screens will possibly aid livestock movement as they neither see the truck ahead nor distracted by whatever may be outside the race.

After the unloading of the livestock, the scales on the columns were examined. The scales maintained their positions above the ground level indicating that there was no consolidation movement. Inspection of the components and especially the joints did not show.any sign of failure.

Conclusion and Recommendations

A wooden ramp for the loading and unloading of cattle to transport vehicle has been designed, constructed and tested. Its use drastically reduced the inhuman treatment of animals during the local loading methods. The exposure of the handlers to injury was also reduced. The structural integrity of the ramp was maintained.

To derive maximum benefit in the use of the ramp and improve animal handling, the race should be extended and curved such that the animal does not sight the truck on entering the race. Screening of the race and guardrails are also suggested.

Test period of longer duration and measurement of possible deflection in the walking platform should be carried out.

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