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STRUCTURAL ENGINEERING

Gang-Nail Construction:

A rational way of fabricating roof trusses for urban and rural housing

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ABSTRACT

The application of punched metal plates in timber construction is a new development, which has gone a long way to rationalise the fabrication of joints in timber engineering. What has hitherto been produced with a lot of labour and time consuming hammering can now be easily and quickly produced by using a punched metal plate with the help of a simple hydraulic press. The joint remains tightly fixed years on end. Furthermore the cost advantages are enormous. One of the most popular punched metal plate is the GANG-NAIL, the structural aspects of which, and the general principles of design and calculation of truss-plated joints are outlined in this paper.

Keywords: gang-nail, fabricators, plate stresses, rooof trusses, timber

INTRODUCTION

When the government of Ghana's policy to embark on a massive housing programme for the people reaches the implementation stage, it will become necessary to produce the various housing components on a mass-production basis in order to make construction economical. In such a massive programme, it will become almost mandatory to produce the roof trusses on a factory fabrication basis. Here, the application of one or the other type of punched metal plate will be very beneficial since up to about 20% cost of the roof structure alone can be saved. This will include savings of timber and labour. Furthermore, trusses can be delivered to the sites as complete units enabling roofs to be erected quicker. This does not only cut down on construction time and developers working capital, but also means that less skilled-site labour can be employed. One of the most established type of punched metal plate (the gang-nail) is discussed here.

DEFINITION

There are at present a number of manufacturers of punched metal plates of various types on the world market, some examples of these are shown in Figure 1.

Figure 2 shows a gang-nail punched metal plate. This is made up of 1 cm to 2 cm thick galvanised fire resistant metal plate with sharp claw like integral teeth.

Gang-nails are only suitable for installation in a factory with special but very simple machinery employed under controlled conditions. Usually fabricators must hold a manufacturer's licence for the use of a particular plate.

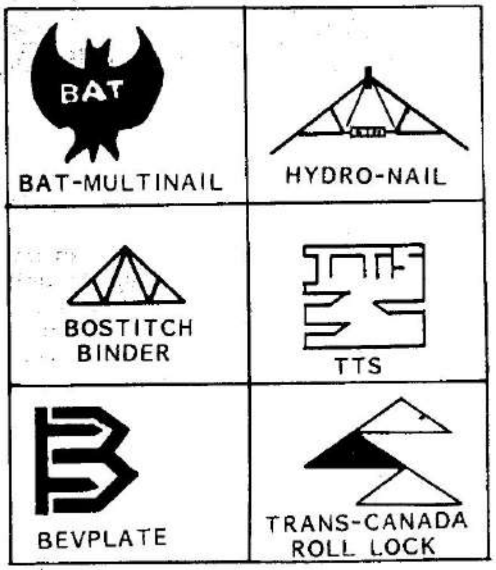
FABRICATION

For the fabrication of gang-nail trusses, only timber pieces of uniform thickness are joined together in one plane. The dry timber members not exceeding 22% moisture content are abutted together, and clamped in a rigid jig before the metal plates are pressed into both sides of each joint using a special hydraulic G-clamp press (Figure 3) Experience in Malaysia using this hydraulic equipment indicates that up to about 100 trusses can be produced per normal working day[1]

APPLICATION

The application of gang-nails are mostly to structures which normally undergo static bending, for example

Fig. 1 FIRMS PRODUCING VARIOUS METAL PLATES



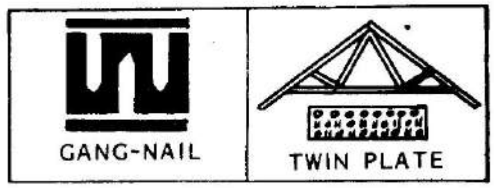


Fig.2 PUNCHED-METAL PLATE (GANG-NAIL)

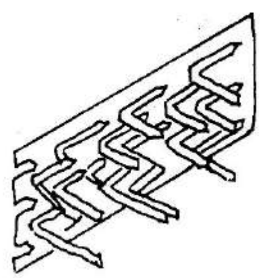
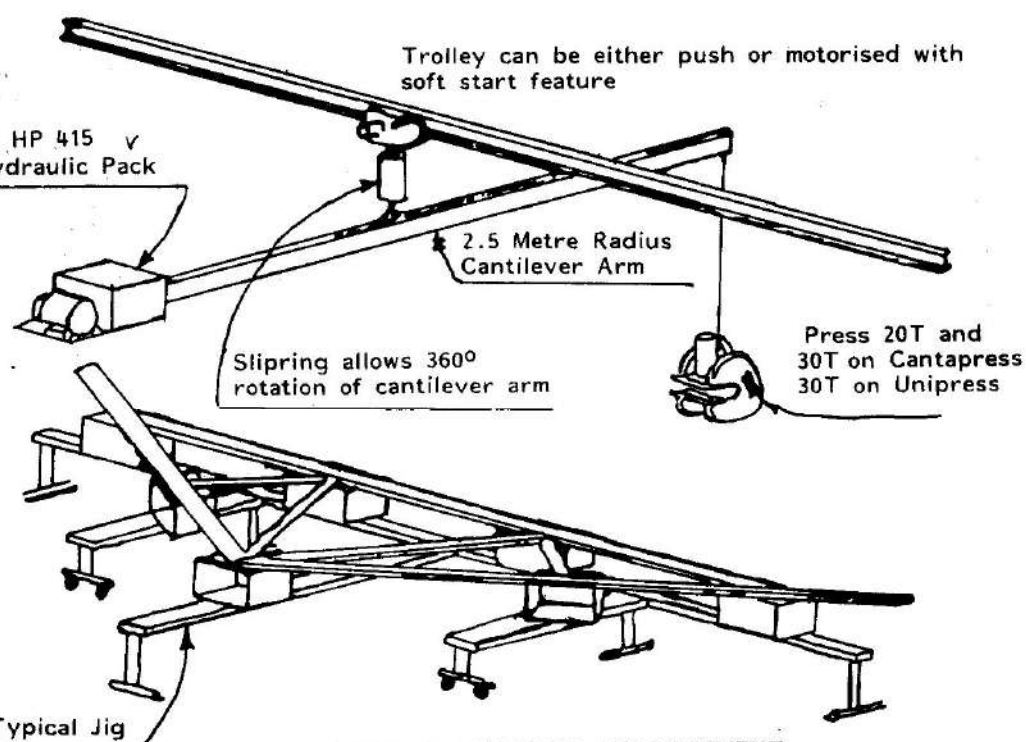


Fig.3 HYDRAULIC G-CLAMP PRESS (CANTAPRESS OR UNIPRESS)



CANTAPRESS OR UNIPRESS ARRANGEMENT

- Roof trusses in triangular forms or lean-to roof trusses for residential or factory buildings.
- 2 or 3-pinned frames for halls of small and medium spans.
- Bracings in a timber construction.
- Walls and ceiling elements
- Scantling frames for concrete work.

When applied in the open or in dampy rooms, the gang-nails must be protected against corrosion.

STRUCTURAL ASPECTS

A few structural aspects of gang-nail construction are discussed here.

- Lattice members are jointed together in the same plane
- The thicknesses of members of a structure with a span of over 12 m must not be less than 50 mm nominal size.
- Only nail plates of equal sizes can be applied on each side of a joint. One plate only must be nailed to each side of a joint. If the joint happens to be a ridge joint of a triangular truss, two plates may be allowed on one side.
- The teeth of the punched plate must penetrate at least 50 mm in the web.
- Every member (also the zero-members) must be checked of their minimal permissible tension load for transportation purposes.
- Abutted-beams in compression must be secured against lateral displacements.
- Strength reduction created in the members as a result of the punched holes is very minimal and need not be considered in the stress analysis.

The following points must be examined in the design of gang-nail connections.

i. Transfer of the loads from the timber to the punched plate nails (Nail stress).

ii. Further transfer of the loads into plate (Plate stress).

NOTATIONS

The following notations are used in Figure 4 and Figure 5 and have been used for the analysis of the nail and plate stresses.

C = Minimum distance from the free timber-edge to the nearest load bearing nail = 10 mm for all types of plates.

Ai = Effective plate area for the calculation of the applied nail load.

A_1 = Gross contact area of plate minus the edge strip.

As = Effective nail plate area in shear. Only the nails which run transversely to the shearing area and lie not more than 0.55 b away, are considered.

Fn = Nail load in (N/cm^2) due to tension, compression or shear. This is further defined as [2] follows:

$$Fn = \frac{\text{Load to be transmitted}}{2 \times \text{effective nail-plate area}} \qquad \text{equation [1]}$$

The permissible load on a nail (Fn adm) depends on the angles α and β where

α = Angle between load and longitudinal direction of plate

β = Angle between load and grain direction of wood.

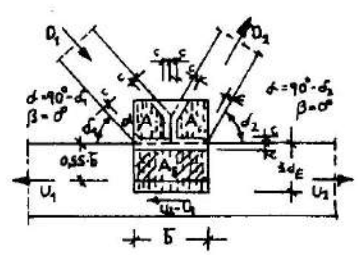


Fig.4 NOTATIONS USED FOR THE ANALYSIS OF NAIL STRESSES

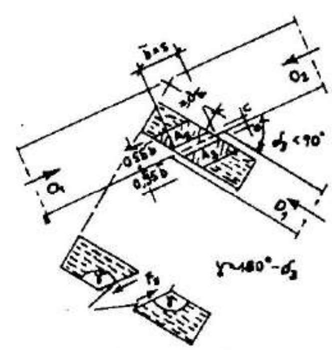


Fig.5 NOTATIONS USED FOR THE ANALYSIS OF THE PLATE STRESSES

S = Effective length of plate at the critical section without the subtraction of the punched holes;

S...lies normally in the contact area of two pieces.

F = Compressive or tensile force on plate in (N/cm).

Fs = Shearing force on plate in (N/cm).

The permissible compressive, tensile or shearing force on the plate depends on the angle S, the values of which are laid down in the gang-nail regulations[5].

S = Angle between longitudinal side of the plate and the intersection line between plate and loaded edge of timber piece.

Tension perpendicular to the grain of wood

The components of a tensile force to the grain should not exceed the values below

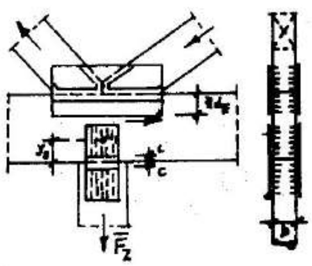


Fig.6 DIRECT LOADING AT THE CONTACT POINT

b = thickness of wood

Ys = distance between the center of gravity of the nailing group and the loaded edge.

for $b \leq Ys$, the permissible tensile force

$$\bar{F}_t \text{ adm} = 130 \times b \times Ys$$

for $b > Ys$ equation [2]

$$\bar{F}_t\text{adm} = b \times Ys \; (1.13 - 0.13 \times \frac{b}{Ys})$$

equation [3]

By indirect loading (e.g. loads hanging on the lower cord, and away from the vicinity of the joint) (Figure 7), the tensile forces which are created through vertical shear and directed into the joint, are:

for $b \leq Ys$

$$\bar{F}^{Q}_t \text{ adm} = 65 \times b \times Ys$$

for $b > Ys$ equation [4]

$$\bar{F}^{Q}_t \text{ adm} = 65 \times b \times Ys(1.13) - 0.13 \times \frac{b}{Ys})$$

equation [5]

$$\bar{F}_t \text{ adm} = \bar{F}^{Q}_t \text{ adm,(left)} + \bar{F}^{Q}_t \text{ adm,(right)}$$

equation [6]

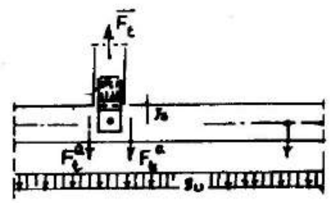


Fig.7 INDIRECT LOADING OF A JOINT

For the gang-nail connection, the eccentricity of the plate need not be considered in the calculations provided the permissible forces are multiplied by the reduction factor n in Table 1. The plates must however always lie symmetrical to the fugus on the web.

Table 1: Reduction Factor n

Slope of Roof s		Reduction Factor n
$\leq$	15°	0.85
15°$\geq$	18°	0.80
18°$\geq$	22°	0.75
22°$\geq$	25°	0.70
>	25°	0.63

Maximum deflection of the members: This can be calculated in accordance to DIN 1052 T1, 10 (See Table 2) or any other accepted standard. The slip modulus of the nail plate may be taken as C = 2000 N/cm per cm^2 effective area of plate.

TABLE 2: MAXIMUM PERMISSIBLE DEFLECTION[4]

Leading	SOLID WEB GIRDERS	DESIGN WITH CAMBER LATTICE GIRDERS		SOLID WEB GIRDERS	DESIGN WITHOUT CAMBER LATTICE GIRDERS	
		APPROX CALCULATION	EXACT CALCULATION		APPROX CALCULATION	EXACT CALCULATION
Pay Load (Working) load	$l/300$	$l/600$	$l/300$	-	-	-
Total load	$l/200$	$l/400$	$l/200$	$l/300$	$l/600$	$l/300$

CONCLUSION

The foregoing method of calculating gang-nail truss plated joints has been Mainly based on the new German DIN E 1052 part 2[3]. The norm is still available only as a draft and offers a very simplified method of how to arrive at the necessary data for the design of a gang-nail timber joint. Meanwhile computer aided design and calculation methods have also been deviced, which help to simplify the work even more.

It is worth noting that the serial fabrication of gang-nail trusses on factory basis affords the architect, engineer and fabricator a lot of time and money saving advantages. Some of these are:

i. The principle of design and structural calculation are simple, and a guarantee of absolute safety is given.

ii. The hydraulic impress of the nail-plate to the wooden joint guarantees a very stiff joint which can stand for years.

iii. Since fabrication is on factory basis supply time is minimised and precision of the trusses is guaranteed. Where a large consignment of trusses are needed, mass production will present no problems.

iv. Mounting of trusses is quick and requires no specialised engineering knowledge on the site.

v. The strength of the joint is by no means reduced as a result of bolt-borings, screws, nails or notches.

vi. No on the site hammering is needed. thereby saving a lot of time and working personnel.

It is hoped, that in the process of promoting our local timbers in the building industry, adequate research work will now go into Ghanaian timbers to find out the species which will be most suitable to take gang-nails.

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