Chapter Four

Case Study & Design

4.1 Introduction

This Chapter deals with the study of designing of Formwork for the flat slab of residential building used as a case study which consists of four floors with an area (2377.6 ft.sq). The study includes design for Sheathing, Joist, Stringer and Shore, according to the requirements of the ACI Committee 347. And the design calculations have been done through excel spreadsheets program following the design steps mentioned in chapter three.

4.1.1 Case study

The plan of the case study used, is shown in Figure (4.1) and in the following there are more details and assumptions about it:

Concrete construction building with building area 2377.6 fit square (202.5 m^2) for the purpose of Design, assume the formwork used to support flat slab floor of a thickness of 7.9 inches (20 cm) and conventional density concrete.

Sheathing will be ply-wood that has the following characterize

- Type : APA B-B ply-form class 1 with species group of face ply = 2 (sanded panels).

- Dry Conditions.

- Thickness = $1\frac{1}{8}$ in (2.85 cm)

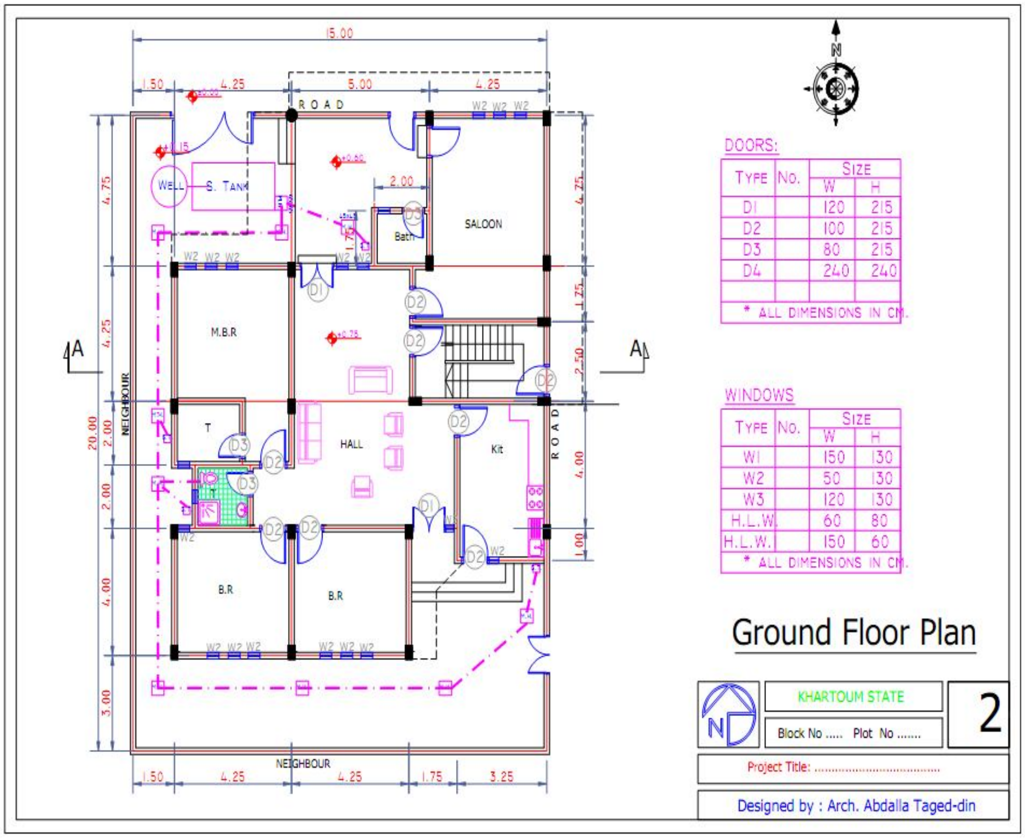

Figure (4.1): Case Study

In the following there are design calculations for the elements of formwork of flat slabs as formulated in the excel spreadsheet.

4.2 Manual Design:

4.2.1Design Loads:

*Dead load = weight of concrete + weight of the formwork

$= {}^{7.9}\!/_{12} in$ of concrete × 150 + 5.0 (assumed)

$= 98.75 + 5 = 103.75 \ Ib/ft^2$

*Live load = 75 Ib/ft^2 (according to ACI = 347).

*Total vertical load = 75 + 103.75 = 178.75 Ib/ft^2

4.2.2 Sheathing :

*Thickness = $1\frac{1}{8} in$. (Sanded panels)

*from Table (3.12) to (3.14) we get the following properties :

Grade stress Level S-2

A = 3.854 in^2

(KS) = 0.820 $in3/ft$

I = 0.548 in^4

Ib/Q = 9.883 $in2/ft$

F_b = 1200 psf

F_v = 140 psf

E = $1.5*10^6$ psf

*Consider 1-ft strip. It carries a load of 178.75 × 1 = 178.75 Ib/ft

From Table (3.15), using 3 or more spans:

Bending:

$$w_b = \frac{120F_b(KS)}{l_1^2}$$

$$178.75 = \frac{120*1200*0.82}{l_1^2}$$

get

$$= \underline{\underline{25.70}} \text{ in} \, l_1$$

Shear:

$$w_s = 20F_v \frac{Ib/Q}{l_2}$$

$$178.75 = \frac{20*140*9.833}{l_2}$$

$$= \underline{\underline{154.027}} \text{ in} \, l_2$$

Deflection:

$$\Delta = \frac{wl_3^{\ 4}}{1740EI}$$

$$< \frac{l_3}{360}$$

$$\frac{l_3}{360} = \frac{178.75 * l_3^{\ 4}}{1740 * 1.5 * 10^6 * 0.548}$$

$= \underline{\underline{28.12}}$ in l_3

Bending governs. Allowable span = 25.70 in

joist spacing = 25.70 /12.5 = 2.056 ft .

4.2.3 Joists:

From Table (3.6) to (3.8), we can get the following values for Redwood (select-structural):

= 1350 psi F_b

=80psi F_v

= 650 psi $F_{c\perp}$

E = $1.4 * 10^6$ psi

Temperature factor C_f = 1.0

Load duration factor C_D = 1.25

Shear stress factor C_H = 2.0 (no split case)

Choose 2×6 Redwood which has the following characteristics:

A = 8.25 in^2

S = 7.563 in^3

I = 20.8 in^4

d = 5.5 in

C_f = 1.20

Load/ ft of joist = 178.75 × 2.056 = 367.51 ib/ft

Bending :

$$F_b^{/} = F_b(C_f)(C_t)(C_D)$$

= 1350 × 1.2 × 1.0 × 1.25 = 2025 ib/ft

From Table (3.16)

$$l = 10.95\left(\frac{F_b^{/} * S}{w}\right)^{1/2}$$

$$= 10.95\left(\frac{2025*7.563}{367.51}\right)^{1/2}$$

= 70.686 in = 5.654 ft

Shear :

$$F_v^{/} = F_v(C_H)(C_t)(C_D)$$

= 80 × 2.0 × 1.0 × 1.25 = 200 psi

$$l = 13.3\left(\frac{F_v^{/} * A}{w}\right) + 2*d$$

$$= 13.3*\frac{200*8.25}{367.51} + 2*5.5$$

= 70.712 in = 5.657ft

Deflection :

$E^{/} = 1.4*10^6\ psi$

$$\Delta < \frac{l}{360}$$

$$l = 1.69\left(\frac{EI}{w}\right)^{1/3}$$

$$= 1.69\left(\frac{1.4*10^6*20.8}{367.51}\right)^{1/3}$$

= 72.587 in = 5.80 ft

Shear governs. Span of joists = 70.686 in ≈ 5.654 ft (OK)

4.2.4 Stringers:

Load on a stringer is = 178.75 × 5.654 = 1010.65 Ip/ft

Use 2×8 (tow stringers)

b = 1.5 in

d = 7.25 in

I = 47.63 in^4

A = 10.88 in^2

S = 13.14 in^3

E = $1.4*10^6$ psi

$C_f = 1.2$

Bending :

$$F_b^{/} = F_b(C_f)(C_t)(C_D)$$

= 1350 × 1.2 × 1.0 × 1.25 = 2025 psi

$$l = 10.95\left(\frac{F_b^{/} * S}{w}\right)^{1/2}$$

$$= 10.95\left(\frac{2025*13.14*2}{1010.65}\right)^{1/2}$$

= 79.45 in = 6.36 ft

Shear :

$$l = 13.3*\left(\frac{F_v^{/} * A}{w}\right) + 2*d$$

$$= \frac{13.3*200*(10.87*2 twostringers)}{1010.65} + 2*7.25 in$$

= 71.719 in = 5.74 ft

Deflection:

$$\Delta < \frac{l}{360}$$

$$l = 1.69 * \left(\frac{1.4*10^6*47.63*2}{1010.65} \right)^{1/3}$$

= 86.04 in = 6.88 ft

Take stringer spacing = 5.74 ft

* Check for crushing (joist on stringer) :

Force transmitted from joist to stringer is equal to load of joist/ft multiplied by the span of the joist, force = 5.654 × 367.51 = 2077.90 Ib

Area through which this force is transmitted = 1.5 × 3 = 4.5 in^2

Crushing stress = 2077.90/4.5 = 461.75 Ib/ in^2

From Table 3.6a , we get the following properties :

= 650 Ib/in^2 $F_{c\perp}$

Bearing area factor = 1.25 (b = 1.5 in)

Temperature factor = 1.0

$$F'_{c\perp} = F_{c\perp}(C_b)(C_t)$$

= 650 × 1.25 × 1 = 812.5 psi since 461.75 < 812.5 (safe in crushing)

Shore strength :

Required shore spacing = (stringer span)

Shore strength = span of stringer × load of stringer

= 5.74 × 1010.65 = 5801 Ib

So we use shores strength is larger than 6000Ib

Design by Microsoft Excel:

4.3 In-put Data [See Figs. (4.2) - (4.4)]

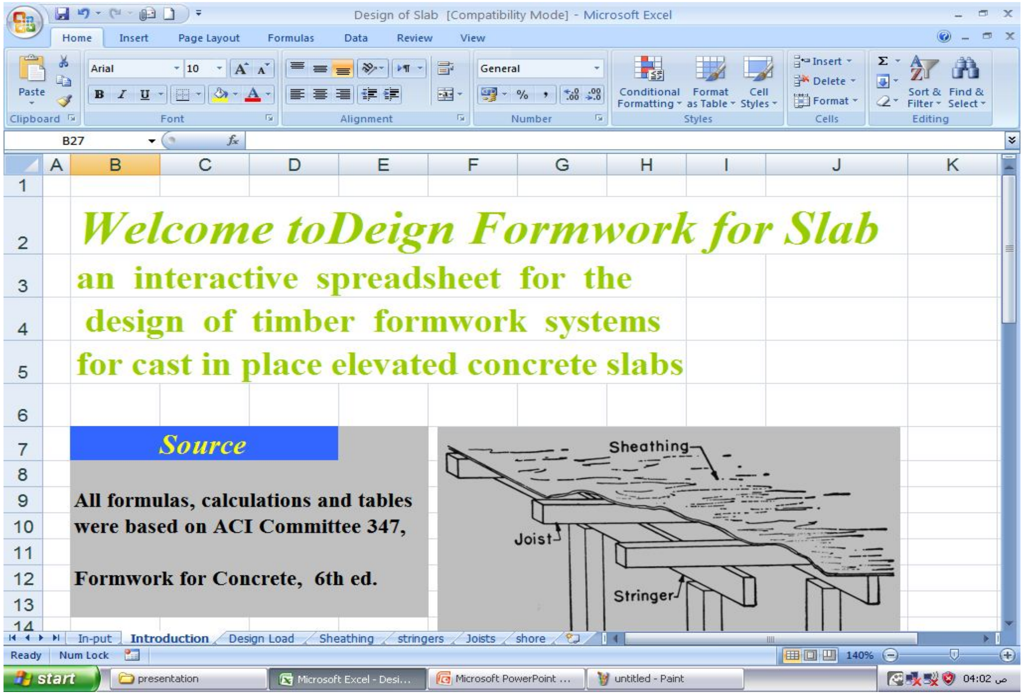

Fig.(4.2): Excel Spread Sheet Menu.

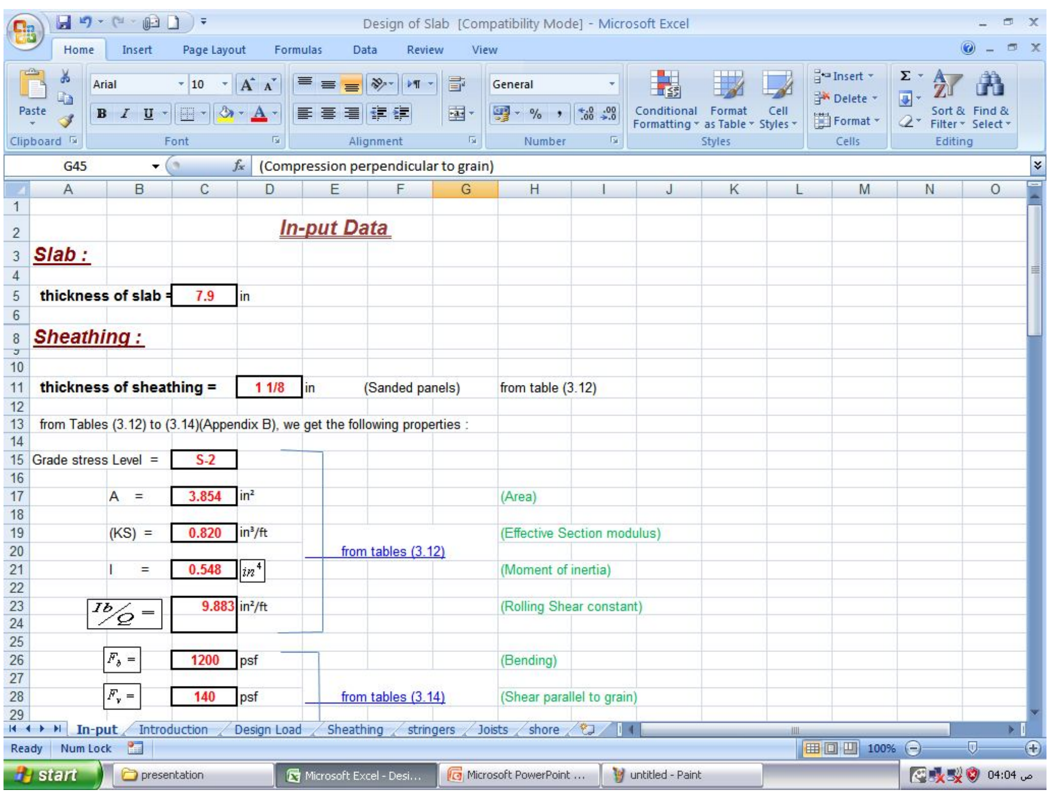

Fig.(4.3): Input data Menu.

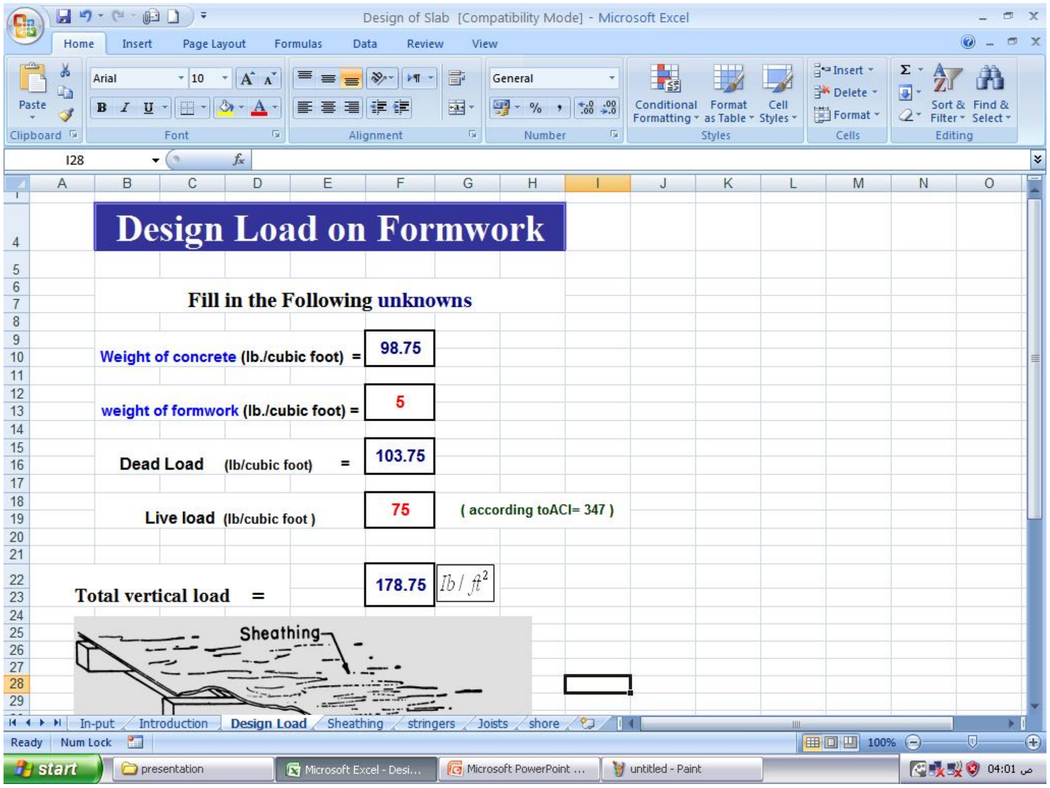

Fig.(4.4): Design Load Menu.

4.3.1 Slab Input

= thickness of slab **7.9** in

Sheathing :

thickness of sheathing = **1 1/8** in (Sanded panels)

from Tables (3.12) to (3.14)(Appendix B), we get the following properties :

Grade stress Level = **S-2**

A = **3.854** in^2

(KS) = **0.825** in^4/ft

from tables (3.12)

I = **0.548**

$Ib/Q =$ **9.883** in²/ft

$F_b =$	**1200**	psf	from tables (3.14)
$F_v =$	**140**	psf	
$E =$	**1500000**	psf	

Joists :

Select type of wood - from tables 3.3 to 3.8(Appendix B) , we can get the following values for Redwood

(Select-
Structural:

$F_b =$	**1350**	psi	from table (3.3)
$F_v =$	**80**	psi	from table (3.3)
$F_{c\perp} =$	**650**	psi	from table (3.3)
$E =$	**1400000**	psi	from table (3.3)

Temperature factor	$C_t =$	**1.0**	from table (3.8)
Load duration factor	$C_D =$	**1.25**	rom table (3.7)
shear stress factor	$C_H =$	**2** (no splite case)	from table (3.4d

Choose (2 *6) Redwood which has the following characteristics :(from table 3.2)

A = **8.25** in²

S = **7.563** in³

I =	**20.8**	in^4
d =	**5.5**	in
C_f	**1.2**	
b =	**1.5**	in

Temperature factor	$C_t =$	**1.0**	from table (3.8)
Load duration factor	$C_D =$	**1.25**	rom table (3.7)
shear stress factor	$C_H =$	**2** **(no splite case**	from table (3.4d)

Choose (2 *6) Redwood which has the following characteristics :(from table 3.2)

A =	**8.25**	in^2
S =	**7.563**	in^3
I =	**20.8**	in^4
d =	**5.5**	in
C_f	**1.2**	
b =	**1.5**	in

Shore :

Bearing Area Factor =	**1.25**	from table (3.9) (b=1.5 in)
Temperature Factor =	**1.0**	from table (3.8)

4.3.2 Design Load on formwork

Weight of concrete (Ib./cubic foot) = **98.75**

weight of formwork (Ib./cubic foot) = **5**

Dead Load (Ib/cubic foot) = **103.75**

Live load (Ib/cubic foot) | **75** | **(according toACI= 347)**

Total vertical load = | **178.75** | Ib/ft^2

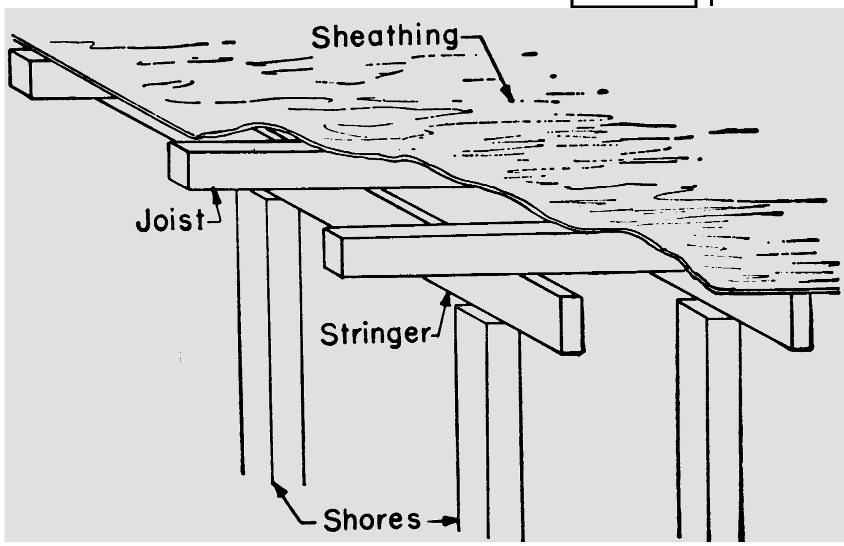

Figure (4.5): Slab Form Components

4.3.3 Design of Sheathing

* Consider 1-ft strip. It carries a load of = 178.75 ib/ft2

From table 3.15, using 3 or more spans :

Bending :

l_1^2 **660.5874**

l_1 **25.70 in**

Shear :

l_2 = **154.81 in**

Deflection :

l_3^3 = **22226.57**

l_3 = **28.12 in**

Joists spacing = **25.70** in

Joists spacing = **2.056** ft

4.3.4 Design of stringer

Load on a stringer is = **1010.79** ip/ft

Bending :

$F_b^\backslash$ = **2025** psi

l = **79.45** in

= **6.36** ft

Shear :

l = **71.764** in

= **5.74** ft

Deflection :

l = **85.70** in

= **6.86** ft

Stringer spacing = **5.741** ft

4.3.5 Design of joists

Load / ft of joist = **367.537** Ib/ft

Bending :

$F_b^{\backslash}$ **2025** Ib/ft

From Table 3.16

l = **70.70826** in

= **5.675** ft

Shear :

$F_v^{/}$ **= 200** psi

l **= 70.70826** in

= **5.657** ft

Deflection :

l **72.55825** in

= **5.80** ft

span of joists = 5.655 ft

4.3.6 Design of Shore

Check for crushing (joist on stringer) :

force transmitted from joist to stringer is equal to load of joist/ft multiplied by the span

of the joist ,

force = **2078.33** Ib

Area through which this force is transmitted = **1.5** × **3** = **4.5** in²

Crushing stress = **461.851** Ib/in²

from Table 3.6a , we get the following properties :

$F_{c\perp}$ = **650** Ib/in²

Bearing area factor= **1.25** from table 3.9

Temperature factor = **1.0** from table 3.8

$F'_{c\perp}$ **812.5** psi **safe** **in crushing**

Shore strength

Required shore spacing = (stringer span)

Shore strength = span of stringer * load of stringer

= **5803.04** Ib

So we use shores strength is larger than **5804** Ib

4.4 Distribution of Joist & Stringers:

4.4.1 Distribution of Joist For length 13.5m (Figure4.1):

Joist spacing = 2.056ft/3.28 = 0.626 m

Span 5 m (net span = 4.7 m)

No of joist = 4.7/0.626 = 7.5 joists

Spacing between joist = 4.7/7.5 = 0.63 m

Span 4.25 m (net span = 3.95 m)

No of joist = 3.95/0.626 = 6.3 joists

Spacing between joist = 3.95/6 = 0.66 m

4.4.2 Distribution of Stringers For length 17 m (Figure4.1):

Stringers spacing = 5.741 ft/3.28 = 1.75 m ≈ 2m

Span 4 m (net span = 3.7 m)

No of Stringers = 3.7/2 = 1.85 ≈ 2 Stringers

Spacing between Stringers = 3.7/2 = 1.85 m

Span 4.25 m (net span = 3.95 m)

No of Stringers = 3.95/2 = 1.97 ≈ 2 Stringers

Spacing between Stringers = 3.95/2 = 1.97 m

Span 4.75 m (net span = 4.45 m)

No of Stringers = 4.45/2 = 2.2 ≈ 3 Stringers

Spacing between Stringers = 4.45/3 = 1.48 m

4.5 Desiccation

- ❖ Design for 1ft strip
- ❖ Design Load for square foot of decking = 178.75 Ib/ft²
- ❖ The type of Sheathing sanded panels (4×8 in) &thick. $1\frac{1}{8}$ in
- ❖ The safe spacing of Joist = 2.056 ft
- ❖ No of Joist for length 13.5m figure 4.1 = 20 Joists
- ❖ Select joist type Red wood (select- structural) carry load = 367.537 Ib/ft
- ❖ Select stringers (2×8) tow stringer. carry Load = 1010.79 Ib/ft and spacing = 5.74 ft
- ❖ No of Stringers for length 17m figure 4.1 = 9 Stringers
- ❖ Force on Shore = 2078.33 Ib & shore spacing = stringers span

Table (4.1): Comparison between Manual Design & Design by Excel

	Manual Design	***Design by Excell***
Design Load	178.75 Ib/ft	178.75 Ib/ft
Sheathing	Load = 178.75 Ib/ft Joist Spacing = 2.056 ft	Load = 178.75 Ib/ft Joist Spacing = 2.056 ft
Joist	Load = 367.51 Ib/ft Span of Joist = 5.654 ft	Load = 367.537 Ib/ft Span of Joist = 5.655ft
Stringers	Load = 1010.651 Ib/ft Stringer Spacing = 5.74 ft	Load = 1010.79 Ib/ft Stringer Spacing = 5.74 ft
Shore	Force = 2077.90 Ib Cruching stress = 461.75 Ib/in² Shore Strength = 5801 Ib	Force = 2078.33 Ib Cruching stress = 461.851 Ib/in² Shore Strength = 5803 Ib

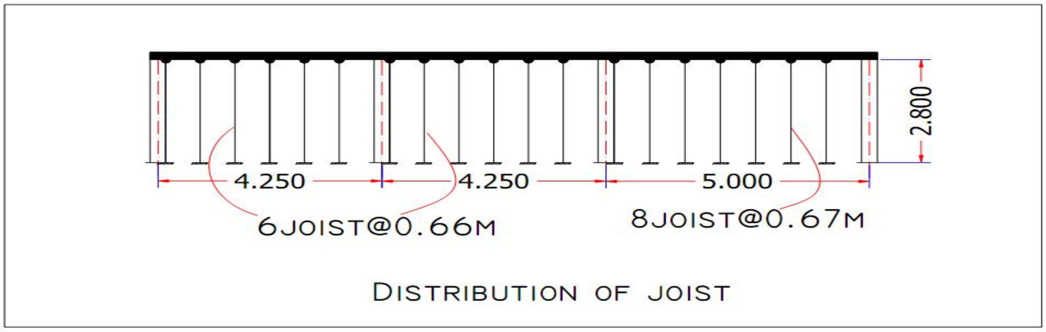

Figure (4.6): Distribution of Joist

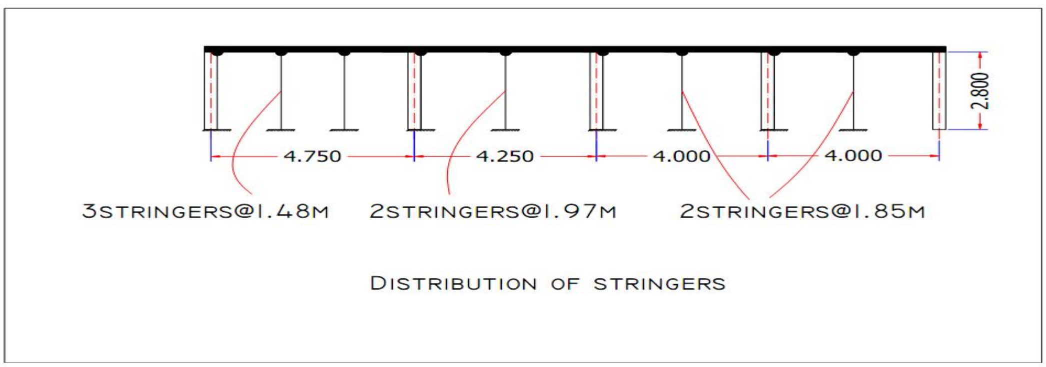

Figure (4.7): Distributions of Stringers