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(Units)

(Masonry)

.(Mortar)

(Circular Arch)

Gothic ) (Parabolic Arch)

(Arch

(Composite Structures)

(Units ,Bricks)

:

Beurman,2009; )

.(1 )

(Mortar)

.(Bjurstrom andLasell, 2009

)

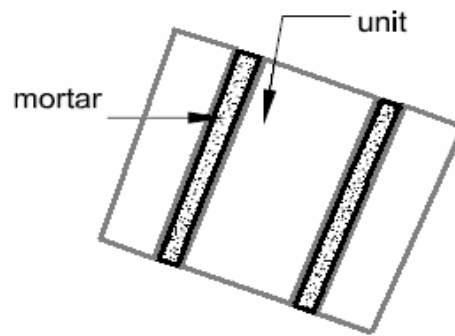
(Thrust Line)

(Eurocode6,2005;BS5628-1:2005

(Masonry)

(Oliveira et al., 2006)

.(2 )



:(1)

(1)

$f_k$  (N/mm<sup>2</sup>)

:(Eurocode6, 2005)

$$f_k = k \cdot f_b^\alpha \cdot f_m^\beta \quad (1)$$

(Sanchez, 2007;Beurman, 2009)

: (3)

:

.(a -3 )

:

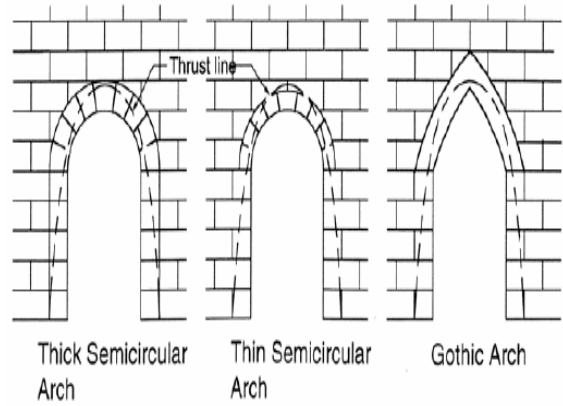
.(b -3 )

$f_b$  :

$f_m$  (N/mm<sup>2</sup>)

$k \beta \alpha$  (N/mm<sup>2</sup>)

(Flat Arches)



:(2)

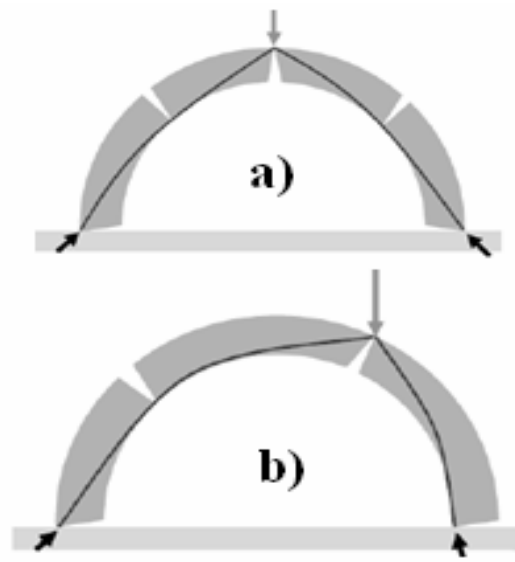
(Sanchez, 2007)

Finite Element )

(Method, FEM

.(Materially Non-linear Analysis, MNA)

(Sanchez,2007)



:(3)

(Beuerman, 2009)

:(Foraboschi, 2004)

750 mm

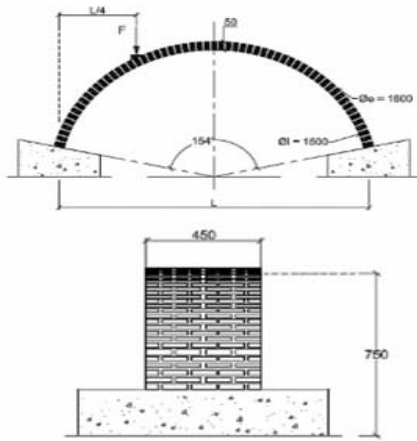
154

800 mm

.50 mm

450 mm

(5)



:(5)

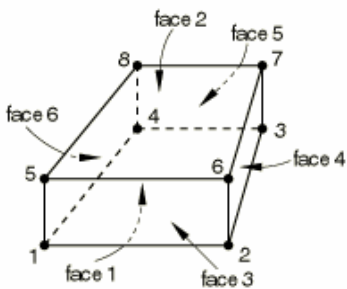
(Sanchez, 2007)

(6 ) C3D8

8

( 3)

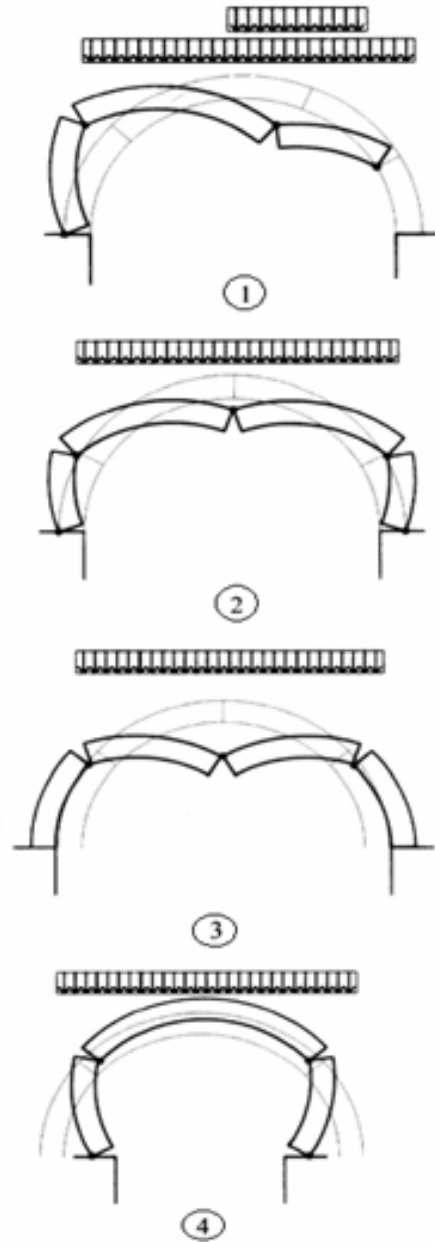
.(ABA QUS Documentation)



8 - node element

C3D8

:(6)



:(4)

(Foraboschi, 2004)

:

-2

(Numerical Analysis Using Finite Element Method)

(ABAQUS -Ver 6.12.1)

(Sanchez,2007)

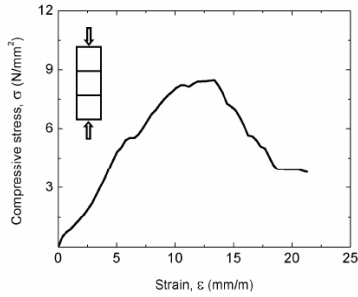
.(5)

(7 ) Spring A Spring 2

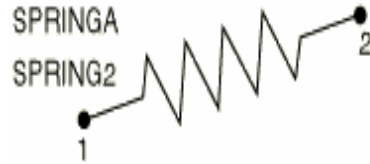
Spring A

(Axial Spring)

.0.0214 (Failure stain)



Spring 2



الشكل (8): علاقة الإجهاد - التشوه النسبي لسلوك القطع الحجرية على الضغط (Sanchez,2007)

:(7)

(9)

(Failure Load)

( $\sigma_{\text{imax}}=0.87\text{MPa}$ )

(Concrete Damage Plasticity-CDP)

ABAQUS

$E_m$  ( $\epsilon_0 = \sigma_{\text{imax}}/E_m = 0.000178$ )

(Sanchez,2007) 4880MPa

CDP (Brittle)

Cyclic )

0.00178

(loading

( $\sigma_0$ )

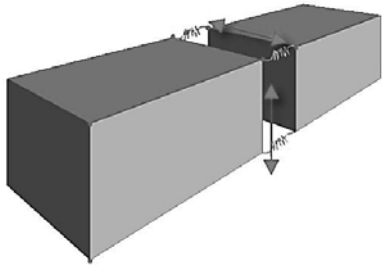
.(ABAQUS Documentation)

(8) .(8) (Sanchez, 2007)

(Stress-Strain)

8.7MPa

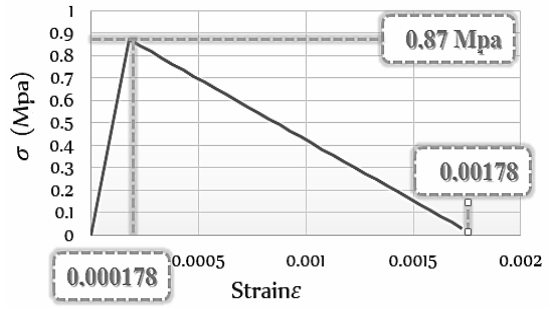
0.015



:(11)

(Numerical Method)

(Mesh Convergence)



:(9)

(ABAQUS Documentation)

(10)

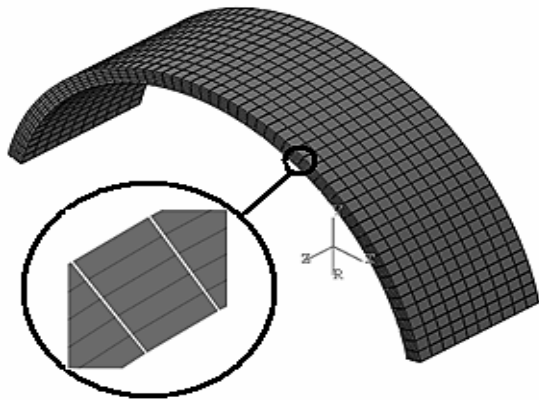
(Spring A)

(Sanchez,2007)

0.003 mm

0.18MPa

(12)



:(12)

(ABAQUS ,ver12-1)

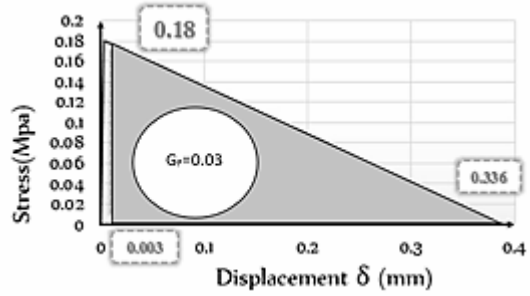
Fracture )  $G_f$

Sanchez (2007)

0.336mm

(Energy

.03 N/mm



:(10)

( ) (13)

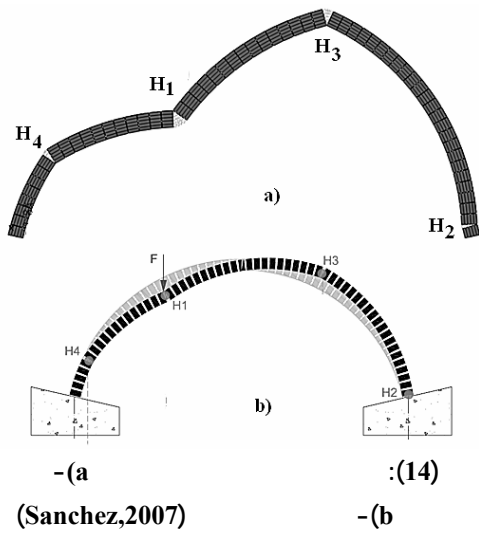
( )

:Spring 2

(11 )

.(Infinity Stiffness)

1.63KN



The effect of ) -3  
 :(loading position and boundary conditions

1.88kN (Sanchez, 2007)  
 .US1 1.38kN US2  
 ) (13)  
 (2013  
 1.61kN

(2013)  
 H1, H2, )  
 (H3, H4

(2013)

(13)

(a - 14)

(13 )

) Sanchez (2007)

(b - 14)

- (15)

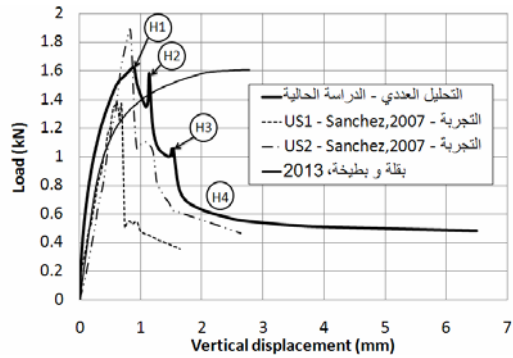
1.61kN

1.63kN

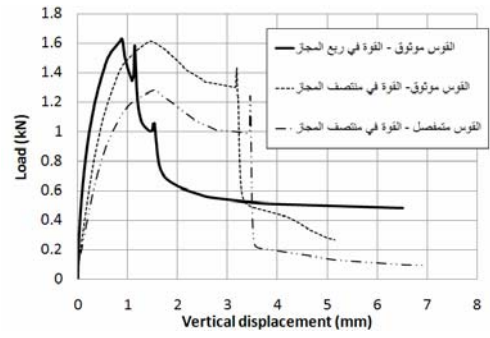
(a - 14)

(Sanchez,2007; Tao etal.,2011)

(15)

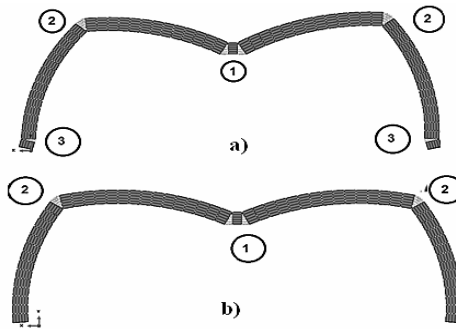


:(13)



(15)

%20



(16)

(b) (a)

(15)

20%

1.28kN

(16)

:(Conclusion)

-4



\*

.10

"

(FRP)

2013 ( )

.25

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