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PAMUKKALE ÜNİVERSİTESİ  
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[ MENKUL DEĞERLER A.Ş. ]

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f g u v g m n g t g " k j v k { c ± " f w { w n f w w " d g r  
d c u n a p o l a n , d i r e n c i c t v o , v , t 0 " D g v q p " o c n | ;  
c t v o c u , p , p " f c { c p , o . " u g j k o " x g " u  
x c t , n U w p w n d w " q n c p " ± c n ± g n o k c n p , n p k' h c n p k  
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## **ABSTRACT**

### **BEHAVIOR OF STEEL FIBER REINFORCED CONCRETE PANELS UNDER OUT OF PLANE LOADING**

**PH. D THESIS**

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**(SUPERVISOR:ASSOC. PROF. DR. FATI H CETISLI)**

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Concrete is the most preferred building material due to its durability, fire resistance, waterproofing, economical production, energy efficiency and on-site manufacturing. The research carried out to reduce the tensile strength of concrete compared to the compressive strength and to try to eliminate and/or reduce this negative feature have led to some developments. One of these developments is the production of fiber concrete. Fibers commonly used in concrete, according to the material from which they are produced, steel, polypropylene, carbon, and alkali resistant glass fibers. The most commonly used of these are steel fibers. In structural applications, steel fiber concrete is not only used to prevent failure, but also to increase the dynamic loading and impact strength of concrete such as explosion, and to prevent shedding, fragmentation and dispersion of the material, steel fiber is added to the concrete. In this study, it is aimed to investigate the importance of parameters affecting the pressure-displacement relationship of steel fiber reinforced concrete panels. Panel thickness, panel dimensions, material type and boundary conditions of the panels are the parameters examined. The steel fiber concrete model to be used in the study has been obtained as a result of various standards and literature research and has been confirmed by the experimental results in the literature. Steel fiber concrete panels were subjected to surface pressure and as a result, it was observed that the as the thickness and the fiber ratio increased, the ultimate bearing capacity increased. It was determined that it may not be enough to support the panels only at the corner points, and intermediate supports are needed. As the support spacing decreased, the absorbed surface pressure increased. In addition, it was concluded that the increase in the amount of steel fiber in the concrete material increased the strength, deflection, and ductility values. In addition, another aim of the study is to obtain a mathematical model that will predict the pressure-displacement relationship of steel fiber concrete panels. When the proposed mathematical model and the analysis results were compared, it was seen that there was a significant relationship between them.

**KEYWORDS:** Steel fiber reinforced concrete, panel element, finite element analysis, surface pressure.

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{ ã | g { " d c u , p e , " k n k m k . u . k . . . \* . . . . . g 245 k n " 3 5 6 ø ã p
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- g m k n 'L~~7L00336~~ 4e  $b/b=0.52$  2 " k ± k p " 4 0 p q m v c - f ã | m k { ' f g r n c u  
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- g m k n 'C7m0367 7g " i  $\frac{3}{4} \pm o g$  " p q m v c u , p c " c k v " f g r n c u o  
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# VCDNQ" N UVGU

## Sayfa

**Tablo 2.1:**  $f_{ck}$  (sırdiřler), ortalama  $f_{ctm,fl}$  ve karakteristik  $f_{ctk,fl}$   
 $N/mm^2$  ek p u k p f g p " g k n  $E_{fg}$  KN/mm<sup>2</sup> c { c p , o " u , p , h n  
q t v c n c o c " u g m c p .v.....g.n.c.u.v.k.u.k.v.g..7 lo q f Ā n Ā

**Tablo 2.2:** P w o w p g " u c { , u , n p o l a p k ' k , d . k . t . . . . . h . q . p . m . u . k 7 4 q

**Tablo 2.3:** N Q R " x g " c t v , m " g k n o g " o w m c x . g . . . . . 8 3 v n g t k " k ±

**g m k n " v c d n q u w " 3/4 g u k " d w n w p c o c f , 0**

**Tablo 4.1:** O c n | g o g n g t " k ± i k e r p . . . . . j . g . u . c . r . n . c . p . c . p . 10 k g t

**Tablo 4.2:** Beton k c t , , o " . . . . . q . t . . . . . p . n . c . t . . . . . 103

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**Tablo 4.4:** M w n n c p , n c p " d g v q p " o c n | g . o . g . n . g . 11 3 " c k v " o g m

**Tablo 4.5:** Sonlu eleman analizinde kullap , n c p " d g v q p . . . . . r . c . t 17 o g v t g n g t

**Tablo 4.6:** R c t c o g v t g n g . t . . . . . x . g . . . . . f . g . v . c . { . . . . . n . c . t . . . . . 118

**Tablo 4.7:** U , p , t " f w t w o n c t . . . . . x . g . . . . . c . ± . . . . . m . n . c . o . b 1 9 c t ,

**Tablo 4.8:** Test matrisi . . . . . 120

**Tablo 4.9:** P k j c k " v c , o c " m c . r . c . u . k . v . g . u . k . . . . . \* . U 1 6 8 7 " k ± k p +

**Tablo 4.10:** P k j c k " v c , o c " m c r c u k v g u k p f g m k " q t v c " p o  
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**Tablo 4.11:** P k j c k " v c , o c " m c . r . c . u . k . v . g . u . k . . . . . \* . U 1 7 0 8 2 " k ± k p +

**Tablo 4.12:** P k j c k " v c , o c " m c r c u k v g ü U 1 6 8 2 " m k ± k p + @ " p o  
. . . . . 171

## UGODQN" N UVGU

<b>b</b>	: R c p g n " { Ã m u g m n k k
<b>b<sub>e</sub></b>	: K, u c " m g p c t " o g u p g v " c t c n , ,
<b>E<sub>fcm</sub></b>	: U g m c p v " o q f Ã n Ã
<b>Ec</b>	: D g v q p w p " g n c u v k u k v g " o q f Ã n Ã
<b>f<sub>ut-FRC</sub></b>	: W N U " k ± k p . " ± c v n c o , " H T E ) p k p " p k j c k " ± g
<b>f<sup>D</sup><sub>150</sub></b>	: C U V O " E 3 8 2 ; 1 E 3 8 2 ; O " v g u v k p f g p " $\frac{3}{4}n \pm \tilde{A}$ mukavemeti
<b>f<sup>D</sup><sub>600</sub></b>	:
<b>f<sub>Ftu</sub></b>	: P k j c k " ± g m o g " c t v , m " o w m c x g o g v k
<b>f<sub>Fts</sub></b>	: D g n k t n k " ± c v n c m " i g p k n k m n g t k " k ± k p " ± v c p , o n c p c p . " m w n n c p , n c d k n k t n k m " c t v , m "
<b>F<sub>R,i</sub></b>	: [ Ã- <del>E</del> O Q F " g Ã   t g t u k k p ' f g m k " k " p q m v c u , p f c m k " c
<b>f<sub>R,i</sub></b>	: G f g g t " g k n o g " c t v , m " o w m c x g o g v k
<b>f<sub>R,3</sub></b>	: ¥ c v n c m " c 4 ± , 7 m ' h o o , p q , n p f w w " k " ? " 5 " p q m v c mukavemet
<b>f<sub>R,1</sub></b>	:
<b>f<sub>fctk,L</sub></b>	: N Q R ø w p " m c t c m v g t <sup>2</sup> k u v k m " f g g t k " * P 1 o o
<b>f<sub>fctm,L</sub></b>	: N Q R ø w p " q t v (N m m <sup>2</sup> ) c " f g g t k "
<b>f<sub>Ftu-FRC</sub></b>	: H T E ) p k p " p k j c k " ± g m o g " o w m c x g o g v k "
<b>f<sub>L</sub></b>	: Q t c p v , n , n , m " u , p , t ,
<b>f<sub>fck</sub></b>	: 4 : " i Ã p n Ã m " m c t c m v g t k u v k m " u k n k p f k t " d g
<b>f<sub>h e m . m Ã</sub></b>	: 4 : " i Ã p n Ã m " m c t c m v g t k u v k m " m Ã r " d g v q p " f
<b>h<sub>sp</sub></b>	: M k t k k p " p g v " { Ã m u g m n k k
<b>i</b>	: 1, 2, 3 veya 4 f g g t k p alt İndisn c p " d k t "
<b>I</b>	: Atalet momenti
<b>k</b>	: C p v k m n c u v k m " g t k n k m " u c d k v k
<b>k<sub>x</sub></b>	: P w o w p g " u c { , u , p c " d c n , " d k t " h c m v $\frac{3}{4}t$
<b>L</b>	: R c p g n " i g p k n k k
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<b>M<sub>c</sub></b>	: C p v k m n c u v k m " g t k n k k p " g v m k n g t k p k " k ±
<b>M<sub>n-RC</sub></b>	: Gelenksel d k t " d g v q p c t o g " m g u k v " k ± k p " p q o k p
<b>M<sub>n-FRC</sub></b>	: H T E " m g u k v k " k ± k p " p q o k p c n " g k n o g " o q o g
<b>n</b>	: p w o w p g " u c { , u ,
<b>SP<sub>1</sub></b>	: 3 0 m c t c m v g t u k v k m " p q m v c " { Ã   g { " d c u , p e ,
<b>SP<sub>2</sub></b>	: 4 0 m c t c m v g t u k v k m " p q m v c " { Ã   g { " d c u , p e ,
<b>s<sub>p</sub></b>	: standart sapma
<b>t</b>	: Panel m c n , p n , ,
<b>1</b>	: 3 0 m c t c m v g t u k v k m " p q m v c " f g r n c u o c p , "
<b>2</b>	: 4 0 m c t c m v g t u k v k m " p q m v c " f g r n c u o c p ,
<b>w</b>	: ± c v n c m " i g p k n k k
<b>w<sub>u</sub></b>	: d g n k t n k " d k t " v c u c t , o " k ± k p " p k j c k " ± c v n
<b>1</b>	: k n m " ± c v n c o c p , p " d c n c p i , e , p f c " ± g m o g "
<b>2</b>	: m c t f w w " c o c " f c n , p , p " d c n c p i , e , p f c m k
<b>3</b>	: { w o w c v o c " m q n w p w p " u q p w p f c m k " i g t k n k c
<b>1</b>	: k n m " ± c v n c o c p , p " d c n c p i , e , p f c " ± g m o g d k t k o " g m k n " f g k v k t o g

2 : m e t c t n , " { w o w c o c " f c n , p , p " d e n c p i , e ,  
 birim g m k n " f g k v k t o g

3 : { w o w c v o c " m q n w p w p " u q p w p f c m k " i g t k n k o  
 f g k v k t o g  
 : g k n o g " g n g o c p , p , p " g t k n k m " { c t , ± c r ,  
 : C p v k m n c u v k m " g t k n k m " r e t c o g v t g u k  
 : R q k u u q p " q t c p ,



## KISALTMA N U V G U

<b>3D</b>	:	3 boyutlu	
<b>4D</b>	:	4 boyutlu	
<b>5D</b>	:	5 boyutlu	
<b>C1F1L1</b>	:	U w 1 ± k o g p v q " q t c p , " 2 0 6 7 . " ± g n k m " n k h " j c	n k h " w   w p n w w p c " u c j k r " q n c p " d g v q p
<b>C1F1L2</b>	:	U w 1 ± k o g p v q " q t c p , " 2 0 6 7 . " ± g n k m " n k h " j c	n k h " w   w p n w w p c " u c j k r " q n c p " d g v q p
<b>C1F1L3</b>	:	U w 1 ± k o g p v q " q t c p , " 2 0 6 7 . " ± g n k m " n k h " j c	n k h " w   w p n w w p c " u c j k r " q n c p " d g v q p
<b>C1F2L1</b>	:	U w 1 ± k o g p v q " q t c p , " 2 0 6 7 . " ± g n k m " n k h " j c	n k h " w   w p n w w p c " u c j k r " q n c p " d g v q p
<b>C1F2L2</b>	:	U w 1 ± k o g p v q " q t c p , " 2 0 6 7 . " ± g n k m " n k h " j c	n k h " w   w p n w w p c " u c j k r " q n c p " d g v q p
<b>C1F2L3</b>	:	U w 1 ± k o g p v q " q t c p , " 2 0 6 7 . " ± g n k m " n k h " j c	n k h " w   w p n w w p c " u c j k r " q n c p " d g v q p
<b>C1F3L1</b>	:	U w 1 ± k o g p v q " q t c p , " 2 0 6 7 . " ± g n k m " n k h " j c	n k h " w   w p n w w p c " u c j k r " q n c p " d g v q p
<b>C1F3L2</b>	:	U w 1 ± k o g p v q " q t c p , " 2 0 6 7 1.5 " ± g n k m " n k h " j c	n k h " w   w p n w w p c " u c j k r " q n c p " d g v q p
<b>C1F3L3</b>	:	U w 1 ± k o g p v q " q t c p , " 2 0 6 7 1.5 " ± g n k m " n k h " j c	n k h " w   w p n w w p c " u c j k r " q n
<b>CDP</b>	:	Concrete Damaged Plasticity	
<b>CMOD</b>	:	Displacement	
<b>exp</b>	:	F g p g { u g n " ± c n , o c " u q p w ± n c t ,	
<b>fem</b>	:	U q p n w " g n g o c p n c t " o g v q f w " u q p w ± n c t ,	
<b>FRC</b>	:	Lifli beton (fiber reinforced concrete)	
<b>LOP</b>	:	q t c p v , n , n , m " u , p , t ,	
<b>RC</b>	:	Betonarme (lifsiz beton-reinforced concrete)	
<b>SP45</b>	:	6 7 " m i 1 o 5 " ± g n k m " n k h " k ± g t g p " d g v q p	
<b>SP60</b>	:	6 0 m i 1 o 5 " ± g n k m " n k h " k ± g t g p " d g v q p	
<b>SFRC</b>	:	¥ g n k m " n k h n k " d g v q p	
<b>SLS</b>	:	j k   o g v " x g t g d k n k t n k m " u , p , t " f w t w o w	
<b>ULS</b>	:	p k j c k " u , p , t " f w t w o w	

“ P U ” \

“ p e g n k m n g ” v Ñ o “ f q m v q t c ” u Ñ t g e k o f g “ g p ” d Ñ  
m q p w u w p w “ d b i l g i s i y l e , ¾ k p p u t c g p m k , k { n n k c k { n g “ m g p f k u k p  
q n f w w o “ u c { i , f g g t “ f c p , o , a p | k p a g ö ± E q ± 0 ö E  
d g p k o “ k ± k p “ d k t “ q p w t f w 0 “ V Ñ o “ g o g m n , g t k p k | “ k :  
hepte var olun hocam.

U c { i , f g g t “ l Ñ t k “ Ñ { g n g t k o “ R t q h 0 “ F t 0 “ g x  
p g n . “ R t q h 0 “ F t 0 “ T g e g r “ D k t i j s a y e n i z d e g d i r “ t 0 “ “ t 0  
i Ñ | g n “ d c m , “ c ± , n c t d g p n k c o | “ c k p ± k p . ± q p m i v f i n g n g t n  
v g g m m Ñ t n g t 0 “

Dr. Ali Kalkanı C p c n k | n g t k o k “ f c j c “ j , | n , “ { c r c d  
m e u c p , “ m q n w p w p “ c n v , p c “ c n , r “ f c “ q f c o f c p “ k ±  
Koridorda y Ñ t Ñ t m g p “ c { c m “ v c d c p n c t , p , “ x w t c “ x w t c “  
¾ | n g f k m 0 “ O g m ¬ p , p “ e g p p g v . “ t w j w p “ c f “ q n u w p .

F g g t n k “ ± c n , o c “ c t m e f c n e t , o “ C t 0 “ I ¾ t 0  
Muhammet Kamal, son ana kadar verdi k p deste k p doştlw wpvw |  
m e v p , , k ± k p “ ± q m “ v g g m m Ñ t “ g f g t k o . “ k { k “ m k “ x c t

D g p k o “ e c p 0 , “ o J c c { k c n v g v o c 0 m k “ g p “ d Ñ { Ñ m “ c p u , o  
f q o c m v , “ u c p , t , o 0 h g ¾ a m g t “ g l o m k n p k | ± k j p g t e “ p Ñ t o n  
J c e , “ G t u w “ x g “ i f e E r p u , s i z l e r e c ± p q p m “ o v “ g g t m m Ñ t “ g f g t k o 0  
q n o c p , p “ d w “ m e f c t “ i Ñ | g n “ b e n i f h e w z a m a n w “ j k u u g v  
desteklef k k p k p “ c d n c o “ D g v Ñ n “ V q m n w o c p . “ m e t f g k  
Tokluman hepinize ± q m “ v g g m m Ñ t “ g f g t k o Ñ t Ñ p v Ñ n g n k { n g h  
d c p c “ g p g t l k “ x g t g p “ x g “ , , m “ u c ± c p “ i Ñ | g n “ {  
D g t t c ø o “ u k | k “ ± q m “ u g x k { q t w o 0 “ J g r k p k | f g “ k { l

m k p e k “ c p p g o ğ p H “ k n k | w p l “ g p e g t p , o f c m k “ v Ñ o  
{ c t f p ö n k ± t k , p “ x g “ W o g w v g t Y n c k m , c n d k k f o l g p v g q m g t v k g g m m  
g f g t k o . “ u k | n g t n g “ c k n g “ q n o c m v c “ ± q m “ d Ñ { Ñ m “  
T c j o g v n k “ d c d c o , | “ [ c c t “ Y c m , d e s e n d i n g v p “ d Ñ { Ñ m “ f  
d w i Ñ p Ñ “ i ¾ t u g p “ p g “ m e f c t “ i w t q w t “ n k { p k , e d c k n , k p { , q “ t x w  
w o c t , o “ d k t “ { g t n . g t f g p “ i ¾ t Ñ { q t u w p f w t

X g “ g k o . “ c p u 0 0 . “ p q n ö v t f n Ñ f n 0 “ O Ñ j 0 “ J c u c  
{ g t k “ i g n f k “ v Ñ o “ u v t g u k o k “ m e t , n c f , p . “ { g t k  
± c n , v , p 0 “ J c { c v , “ d c p c “ m q n m { n f k , ± v k , p p “ f u , c p , c p “ k  
o k p p g v v c t , o 0 “ J c { c v “ u g p k p n g “ ± q m “ i Ñ | g n “ k { k

## 1.1 T

F c { c p , m n , n , , . " { c p i , p c " m c t , " f k t g p e k . ' x g t k o n k n k k . " { g t k p f g " k o c n c v " i k d k "  $\frac{3}{4}$  | g n n k m o c n | g o g u k f k t 0 " D g v q p w p "  $\pm$  g m o g " f c { c p , o , p , p " c b u o n w o u w | "  $\frac{3}{4}$  | g n n k k p " i k f g t k n o g { g " x g l x g { c " c t c v , t o c n c t " d c | , " i g n k o g n g t k p " q t v c { c "  $\pm$  , d k t k u k " f g " n k h n k " d g v q p n c t , p "  $\tilde{A}$  t g v k n o g u k f k t 0

N k h n g t " o g v c n k m . " r q n k o g t k n o g o g o g t p f g g p ' h d x w N k h n k " d g v q p "  $\frac{3}{4}$  | g n n k m n g t k p k " g v m k n g { g p " g p "  $\frac{3}{4}$  d g v q p " o c v t k u " k  $\pm$  k p f g " j q o q l g p " q n c t c m " f c , u c { , n c d k n k t 0 " D w "  $\pm$  c n , o c f c " d g v q p g " i u  $\frac{3}{4}$  j k r  $\pm$  q n  $\pm$  g n k m v g m k . " {  $\tilde{A}$  m u g m " x g "  $\tilde{A}$  p k h q t o "  $\pm$  g m o g " i g t k n { c t c t n c p o c m " c f , p c " d g v q p c " m c v , n c e c m " n k h n g t

$\forall$  g n k m " n k h n k " d g v q p n c t n c t " u q p " { x , c n c m c c t p f , c " = ' x g " n k o c p n c t f c . " d e t e l " k p c c v n c t , p f c . " d g v q p  $\pm$  c n , o c n c t , p f c " x g " r c v n c o c { c " m c t , " f c { c p , m m e v m , n c t , " x g " g p g t l k " { w v o c " m e r c u k v g u k p k p k w n n c p , n o c m v c f , t 0 "

R c v n c o c " {  $\tilde{A}$  m n g t k p g " f c { c p , m n , " { c r , " v c u c t { , m , n o c o c u , " x g "  $\frac{3}{4}$  n  $\tilde{A}$  o e  $\tilde{A}$  n " j c u c t n c t c " p g f g p " q n x g " g v m k { g e g m " m w x x g v n g t k p " d  $\tilde{A}$  {  $\tilde{A}$  m n  $\tilde{A}$   $\tilde{A}$  " v c o " q v c j o k p " g f k n o g u k " u q p w e w p f c " j g t " v  $\tilde{A}$  t n  $\tilde{A}$  " o  $\tilde{A}$  j g M w n n c p , n c d k n g e g m " r c v n c { , e , " o k m v c t , . " r c v n o g u c h g " x g " d g p | g t k " r c t c o g v t g n g t " d k n k p k t u g hesaplanabilmektedir.

[ c r , " {  $\frac{3}{4}$  p g v o g n k m n g t k p f g " v g t  $\frac{3}{4}$  t k u v " u c n f , v c u c t , o , p c " k n k m k p " j w u w u n c t , p " i  $\frac{3}{4}$  | " c t f , " g

t  $\tilde{A}$  | i  $\neg$  t . " u g n " i k d k " { c r , n c t , " x g " k  $\pm$  k p g f g k " { c c  
kabul edilmelidir.

### 1.1 R t q d n g o k p " V c p , o ,

[ c c f , , o , | "  $\pm$  g x t g f g m k " j g o g p " j g o g p " v  $\tilde{A}$  o  
{ c r , o , p f c " m w n n c p , n c p " v g o g n " o c n | g o g = " m q n c  
v g m p k m "  $\frac{3}{4}$  | g n n k m n g t k p f g p " f q m m c " {  $\pm$ , g " m d o g g v " q f p c f { w c t p 0 , " o  
q n c p " d g v q p w p " | c { , h "  $\frac{3}{4}$  | g n n k m n g t k p k p " d g n k t i l  
d g v q p " k  $\pm$  g t k u k p g " f g k k m " o c n | g o g n g t " m c v , n c

I  $\tilde{A}$  p  $\tilde{A}$  o  $\tilde{A}$  | f g " d g v q p w " f g k k m "  $\alpha$   $\pi$   $\rho$   $\eta$  c  $\pm$  t, f m c o " c m v  
d g v q p " v g m p q n q l k u k p f g " d c | , " i g n k o g n g t k p " { c  
d k t k u k " f g " n k h n k " d g v q p n c t , p "  $\tilde{A}$  t g v k n o g u k f k t  
q n w c d k n o g m v g f k t 0 " P c t k p n k m " q h o m o g e n o l a " a k n k h " o k  
f c , n o c u , . " n k h k p " v k r k " x g " i g q o g v t k u k " n k h  
h c m v  $\frac{3}{4}$  t n g t f k t 0 " D w t c f c m k " p c t k p n k m " q t c p , " \* C  
 $\frac{3}{4}$  p g o n k " p  $\tilde{A}$  o g t k m " r c t c o g v t g + . " n k h e l d e d i l e n w p w p " g  
 $\tilde{o}$  d q { 1  $\pm$  c r  $\tilde{o}$  " \* c u r g e v " t c v k q + " q t c p , f , t 0

$\forall$  g n k k p " g n c u v k u k v g " o q f  $\tilde{A}$  n  $\tilde{A}$  p  $\tilde{A}$  p " f k g t " n k h  
 $\pm$  q m " f c j c " d  $\tilde{A}$  {  $\tilde{A}$  m " q n o c u , p f c p " f q n c { , " { c r , { c " i  
v  $\tilde{A}$  t n g t k p g " i  $\frac{3}{4}$  t g " c x, c e p c v " c  $\pm$  l g " n u k c m " m c k o h c n n g v t c k f p , " t g 0 p " "  $\frac{3}{4}$  p t  
x g "  $\tilde{A}$  p k h q t o "  $\pm$  g m o g " i g t k n o g n g t k p g " m c t , n , m  
u g d g r n g " d w "  $\pm$  c n , o c f c " d g v q p " k  $\pm$  k p g " m c v , n c e c

$\forall$  g n k m " n k h n k " d g v q p "  $\forall$  w n w g o w " m w n p g p , g a g o  
d c u , p e , " x g t k n o k " x g " r c p g n n g t k p " f c x t c p , n  
m c n , p n , , . " o c n | g o g " v k r k " x g " o g u p g v n g p o g "  
q n w v w t o c m v c f , t 0 " G n f g " g f k l i f l i g b e t o h u c m e k a n i k | " u q p  
 $\frac{3}{4}$  | g n n k m n g t k p k " v c j o k p " g f g e g m " o c v g o c v k m u g n "

## 1.2 C o c ± " x g " M e r u c o

V Ñ t m k { g " i k d k " f g r t g o " m w c , p f c " { g t " c n c p  
d k n k p g p " d g v q p w p " d w " | c { , h " { ¾ p Ñ p Ñ p " l i k l i { k n g v  
d g v q p w p " { c r , p , p " u Ñ p g m n k k p k " c t v v , t f , , " d l  
d g v q p " u c f g e g " m , t , n o m a k t a . " " ¾ p { n p g , o " g l n c " o k c ± p k f p c " " n d v g n v n q  
i k d k " f k p c o k m " { Ñ m n g o g " x g " f c t d g " o w m c x g o g v k  
p a r ± c n c p o c " x g " f c , n o c u , p , " ¾ p n g e t o l g e k t e d i k ± k p " f g "

R c v n c o c " d Ñ { Ñ m " o k m v e t f c " g p g t l k p k p " ± c d w r  
q n w c p " d k t " q n c { f , t 0 " R c v n c o c p , p " { c r , n e t " Ñ  
q t v c { m g p ± . , " m i c Ñ p Ñ o Ñ | f g " u k x k n " j c { c v v c " f c " v g t  
d c n c o , v , t 0 " D w " m q p w p w p " m e r u c o c " c n c p , p c =  
r c v n c { , e , " i c | " x g " u , x , " f g r q n e t , p , p " { c r , o ,  
i k d k " r n g " h u c f n f e . , t " . k { c " w t c { c d k n g e g m " { c r , n e t "

D w " v g | " ± c n , n o p . f i " , ± g m k m " m g p h n k f c " c p k n f i g p k  
m a k s a t i l e m w n n c p , n e d k n o g u k " ¾ p i ¾ t Ñ n g t g m " r c t c o  
i k f k n B u k a p s a m k l a t f Ñ | n g o " f , , " ± Ñ m n g o g u g t " g g a " k i m e ¾ t t n Ñ m g n  
d g v q p " r c p g n n g t " d k t " ± g t ± g x g " u k u v g o " k ± k p f g  
e t k i g v o g u k " o w j v g o g n " q n c e c , p f c p f " Ñ d m g o r " c p g k  
{ Ñ m n g o g n d a f g " m p e , t e m e s i n i i ¾ g e r e k l i o l a b i l e e g k " f g g t . n g p f k t  
D w " m e r u c o f c " g n g " n e k n t , k p c " p v " g r q c t p k g u n k n p g g t " " { k c ± n k , p p " q n  
o q f g n n g t " q n w v w t w n o w v w t 0 " C t f , p f c p " m k t k  
{ q n c " g p m o w ± o n d i n k p c " ± g " m o g " f c { g c p g , t o n , g p p c f " k w t n k e n o v k , v  
s o n r a d a ± g n k m " n k h n k c " r d g u k y p g " r c p g t n d k p " " w n c c d k n f k  
u q p t c m k " f c x t c p , , p c " f c k t " d k n i k " v q r n c p o c { c  
h c t m e , c n c f p f i n c p f " , " u ¾ | p g , n t n " k m g n v g u k n k t f g , g t n g p f k t o g  
U , p , t " m q w n d g m n g p g p k g " Ñ | g o k p i f ¾ g t " Ñ f n c o x Ñ t c v p Ñ , t 0 ,  
c u n , p f c " d g m n g p k o g p ; p k t t c c a g p p n k v g t c v Ñ t f g  
t c u v n c p d N k o v , g t c , v t Ñ 0 " f g " d q { w v n e t n e " k n i k n k " x g {  
\* m q o w " k m k " m g p c t " u Ñ t g m n k . " m e t , " k m k " m g p c  
v w v w n w " i k d k o l s a k a f k n k , " ± c m q w n n c t , " p , p " d w " v g |  
c t c , m " , n m e u , . " { c n , p " j c n k { n g " f Ñ | n g o " f , , " { Ñ |

engellenmesi durumu j k ± " f g g t n g p f k t k n o g o k v k t 0 " " Dw  
n k v g t c v ã t g " d k t " m e v m , " u c n c { c e c , " f ã ã p ã n c

### 1.3 F c j c " " p e g " [ c r , n e p " ¥ c n , o c n e t

V g | " ± c n , o c u , " m e r u c o , p f c " k p e ã g t c g p n g , p m " ¾ p  
c n v , p f c " v q r n e p o , v , t 0 " D w p n e t f c p " k n m k " ± g n k  
{ ¾ p g n k m " { c r , n e p " f g p g { u g n " x g " D w ã o ± g t n k , m " o e n n  
f g g t n g m p f k g k h n g t g n k h n k " d g v q p w p " d c u , p ± " x g  
o q f g n n g p o g u k " c c o c u , p f c " i g t g m n k " m k n p c e d k k " n g  
d c n , m v c . " ± g n k m " n k h n k " d g v q p n e t , p " r c v n c o c  
± c n , o c n e t " g [ n e g r " , c n n c , p p " o k p m e v g r f g d g n g t " p g v k e g u k  
± g n k m " n k h n k " d g v q p " r c p g n n g t k p " f c x t c p , , p  
f g g t n g p f k t o g n g t " { c r , n o c { c " ± c n , , n o , v , t  
, , , " c n v , p f c " p ± g g n m k g m " k p k h f n ã k | " n d g g v q f p , " r ç { ã | g  
± c n , o c n e t , " j e t k ± + " v e d k " v w v w n o c n e t , " f w t w o  
{ g t " c n o c f , , " i ¾ | n g o n g p o k v k t 0 " D w " u g d g r n g .  
x g " v c u c t , o " m q ã n ã c e t ã , " d g u c n u , " m e v r c , " p v e g t | c " m e c n , o c u ,  
x g " o c v g o c v k m u g n " o q f g n f g " m w n n e p , n e p " r c t  
f g g t n g p . f k t k n o k v k t

#### 1.3.1 U H T E ø p k p " O g m e p k m " " | g n n k m n g t k " k n g " n

Barros ve Figueiras \* 3 ; ; 9 + . " d g v q p " { g c " r o , q n f c w p , w p " d f k c t x k t p c  
ã | g t k p f g " ± g n k m " n k h n g t k p " g v m k u k p k " k p e g n g  
q t c p n e t , { n c " v e m x k { g " g f k n o k " n g x j c " g t k v  
M w n n e p , n e p " n k h " k ± g t k k p g " i ¾ t g { ã m v n c o ç ö d  
m e r c u k v g u k " x g " u ã p g m n k m v g " ¾ p g o n k " d k t " c t v ,  
± c v n c m " c t e n , , " i ¾ | n g o n g p o k v k t 0

I c q " x g " f ,k{ c0r "o \* 3 ;" ;q9n+f w u w t e u n { n o 'e f 7 0 6 " O R  
O R c ) { c " m e f c t " d c u , p ± " x g " k m k g a g ' e b w m c m g d g g k  
o w m c x g o g v n k . " j c h k h " d g v q p w p " o g m c p k m " ¾ |  
u w p w n o c m v c f , t 0 " ¥ g n k m " g n { c h , p " g u p g m n k m " o q  
g v m k u k " c t c v , t , n o , " x g " g k n o g " n i f h a c m i n o c " v q  
h t c m u k { q p w p w p " x g " g p " d q { " q t c p , p , p " g k n o g "  
g v m k u k p k p " u q p " f g t g e g " d g n k t i k p " q n f w w p w .  
k { k n g v k t k n f k - d k u p , k p ± " x g o ' w m g x k o g o g k " q t c p , p , p  
i ¾ u v g t o g m v g f k t

[ c r , n e t , p " c p e n k | k " x g " v c u c t , o , " k g m k p n " d c u  
f g k v k t o g " g p c t v k c u t k c " l i c g " t x g g n i f k k f k 0 t " 0 \* h 3 f ; w ; w " ± c n ,  
7 2 " O R c " c t c u , p f c " f g k g p " d c u , p ± " f c { c p , o c "  
d e n e y s e l o l a r a k g e r i l m e - g m k n " f g k v k t o g " g t k u k p k " q n v  
{ c r , n o , v , t 0 " © ± " h e t m n , " j c e k o " h t c m u k { q p w p c  
c n , p e t c m . " d g v q p c " n k h " g m n g p o g u k p k p " r k m " i g t  
d g v q p w p " v q m n w w " Ñ | g t k p f g m g m k n k g n v " n f k g u k k " c v t k e t o v g ,  
j g o " { Ñ m u g n g p " j g o " f g " c | c n c p " m , u , o n c t , p , "  
¾ p g t k n o k v k t 0

U q p " | c o c p n e t f c . " { g t c n v , " k p c c v n e t , p f c  
d g v q p 1 r Ñ u m Ñ t v o g " d g v q p " k n g " f g k v k t k n o g u k  
± g n k m " n k h n k " d g v q p " x g " i g n g p g m u g n " d g v q p c t o  
v c , o c f n k v p c i f " , x t g 0 " M o w k u w " g ± a n g , " ÷ d o g f c " \* 3 ; ; ; + . " r c p g  
g k n o g " u Ñ p g m n k k p k p " i g n k k o k p k " f g g t n g p  
n e d q t c v w x c t " d g v q p w " Ñ | g t k p f g " f g p g { u g n " c t  
| , o d e n e o c " m e r c u k v g u k p k t ' d Ñ ± Ñ m k ¾ Ñ Ñ Ñ 2 g y h i c t o f  
i g n g p g m u g n " d g v q p c t o g f g m k " | , o d e n e o c " i ¾ ± o g  
v c m x k { g u k . " g k n o g " m e r c u k v g u k p k " ¾ p g o n k "  
c d u q t r u k { q p w . " 3 2 " k n c " 5 2 " u c c v v g ' B u U 4 0 T E 8 2 ) ,  
m i 1 o 5 ) n Ñ m " n k h " k ± g <sup>3</sup> t e k t c k u p , k p p f . c " m 6 2 " f k q n e ' l 8 2 l ' ¾ m i g  
g m q p q o k m " p q m v c " q n e d k n g e g k " c p n c o , p c " i g n o g

[ Ñ m u g m " o w m c x g o g v n k " d g v q p w p " \* J U E + " f Ñ Ñ  
m e r c u k v g n g t k " k n g " d g k p t i g l m p ' g m o g u k s o n g v a g , " m . " , ±

Hwang (2004) { c r o , " q n f w m n c t , " ± c n , o c f c . " { Ã m u g m  
d g v q p w p " o g m c p k m " ¾ | g n n k m n g t k p k " c t c v , t o ,  
i g t k n o g " o w m c x g o g v n g t k . " u n k q " r d o v e n " w o p q o f c Ã m v Ã c " f x , g t " 0 v " o  
' " 2 0 7 . " ' 3 0 2 . " ' 3 0 7 " x g " ' 4 0 2 " j c e k o " h t c m u k {  
d g v q p w p " d c u , p ± " f c { c p , o , . " J U E ) { g " i ¾ t g " ' 3 7 .  
j c e k o " h t c m u k { q p w p f c " w n c v r i l h e " n k k a v e n " l e t i v e m x k { g n  
m q r o c " o q f Ã n Ã . " j c e k o " h t c m u k { q p w p w p " c t v v  
h t c m u k { q p w p f c " u , t c u , { n c " ' ; : 0 5 " x g " ' 3 4 8 0 8 " v  
v q m n w m " g p f g m u k . " h t c m u k { q p w p " c t v v d c u n p ± ù , {  
x g " { c t , n o c " i g t k n o g " o w m c x g o g v n g t k p k " x g " m  
o w m c x g o g v " o q f g n n g t k " q n w v w t w n o w v w t 0

Olivito ve Zuccarello (2010). " ± g n k m " n k h " v c m x k { g n k " d g v q  
k ± g t k k " x g " m c t , , o " v c u c p f o t p x g n o g e " a c u n { o q , p n v c , t t , 0 "  
m c t , , o " v c u c t , o , " \* n k h " k ± g t k k " ' 3 " x g " ' 4 + "  
m c t , , o n c t " j c | , t n c p o , " x g " n k h n k " d g v q p w p "  
v g m " g m u g p n k " u , m , v , t o c p v g u v n g ' t x l g " { Ã p g m o k m v  
g n f g " g v o g m " k ± k p " ± g p v k m n k " p w o w p g n g t " Ã | g t k  
¥ g n k m " g n { c h " v c m x k { g n k " d g v q p w p " \* U H T E + " ± g m c  
j g o " f g " c p c n k v k m " d k t " o q f g n f i g p g { u n g w m " n u q p w ±  
f c { c p c t c m . " n k v g t c v Ã t f g " d k n f k t k n g p " x g " f c  
d g n k t n g p o g u k p f g " m w n n c p , n c p " c p c n k v k m " d k t  
{ c r o c m " c o c e , { n c " w { i w n c p o , v , t " x g " k { k " d k t "

U w u g v { q . (2011) , " ± g n k m " n k h n g t k p " d g v q p " ± c v n c  
g v m k p n k k p k " f g g t n g p f k t o g m " k ± k p " f Ã | n g o " k  
c n v , p f c " q p " c f g v " d g v q p " r c p g n " v g u v " g v o k v k  
f k t g p e k " x g Ã ± ¾ v g a m k m q p v k ù n g t i k n g { g p " d g v q p  
± g n k m " n k h " v c m x k { g u k { n g " g n f g " g f k n g d k n g e g l

M¾ m u c n " x g ø f k ø r 0 " , \* 4 " 2 q 3 n 5 f + w w " d w " ± c n , o c p , p  
v c m x k { g n k " d g v q p " \* U H T E + " r e n m u n k n o c k t | " g k " ± g k f p g . t " g r m " c x r  
o c n k { g v n g t k p k " o k p k o k | g " g f g t g m . " q r v k o w o "  
q n w v w t c p " q r v k o w o " d k t " m c t , , o " v c u c t , o , "  
8 2 2 z 8 2 2 z 3 2 2 " o o " d q { w v n c t , p f c " 8 2 " r n a r a k m " ¾ t p g



Ãt g v k n k r " x g " v g u v " g f k n o k v k t 0 " F g p g { u g n " u c  
v c u c t , o , p , " d g n k t n g o g m" k ± k p " ± q m" c o c ± n , "  
m w n n c p , n o , v , t 0 " Q r v k o k | c u { q p " u , t c u , p f c " f k  
k ± k d p g " t h k g t k p " g p " d q { " q t c p , " x g " j c e k o " q t c p , f  
v c u c t , o , " d g n k t n g p o k v k t 0

Q w " x g " f k " 0 ± " g \* n 4 k 2 m 3 " 4 g + n { c h " v c m x k { g n k " d g v q p  
k p f g m u k p g " u c j - i k g t " k d p k u a " p f ± d " x i t g d p k , n o , g p , " d i r e c t c m v g t  
Ã | g t k p f g " u , m , v , t o c " v g u v n g t k " i g t ± g m n g v  
q t c p n c t , p c " u c j k r " ± g p i g n " w ± n w " n k h n g t " f k m n  
U H T E ) p k p " g u p g m n k m " x g " d c u , p ± " f c { c p , o , " o q f  
± g n k m " h k d g t n g t " x g " f c j c " f Ã Ã m " g p " d q { " q t c p ,  
d Ã { Ã m " d k t " c t v , , { n c " u q p w ± n c p f , , " i ¾ t Ã n o Ã

R c t m " x g " f k k Ø " f \* , 4 2 " 3 q n f w w " ± c n , o c f c . " m w  
[ Ã m u g m " R g t h q t o c p u n , " b u r k ( U H P - U H T E n { á l g t V a m x k f g n  
Ã | g t k p f g m k " g v m k n g t k " c t c v , t , n o , v , t 0 " F ¾ t  
i g q o g v t k { g " u c j k r + " x g " d k t " v k r " ± g n k m " o k m  
Ã t g v k n o g u k p f g " o c m t q " h k d g t n k p i k r o j f i b e r i n k h a c i m k ± g t k  
k ± g t k k " ' 2 0 2 " k n c " ' 3 0 7 " - H F R C h i n g e p i l m e c g e r i l m e - k o g m  
i g t k p k o " g t k n g t k p k p " i - r g l p l g " n v k r g k m p g k . d c u r e , u f " , q t n  
n k h n g t k p " g m n g p o g u k . " i g t k p k o " u g n w a g w b e g ¾ k p g  
g v m k n g o k v k t 0 " D Ã m Ã n o Ã " i g q o g v t k - H F R C , u c j k r "  
± c v n c o c " u q p t c u , " o w m c x g o g v . " i g t k p k o " m e r c u  
c ± , u , p f c p " g p " k { k " r g t h q t o c p u , " u c n c t m g p . " v  
H F T E " g p " m ¾ v Ã " r g t h q t o c p u , " i ¾ u v g t o k v k t 0

¥ g n k m " g n { c h " v c m x k { g n k " d g v q p " \* U H T E + " v g c  
i g t k n o g n g t k " ¾ n ± o g m v k t 0 " N k h n g t n g " d g v q p " g v  
i g t k n o g n g t " c f , " x g t k n g p k " t ± " g d n ¾ g Ã " o i Ã p t Ã k " n v c g n , g t c k d  
g m k n " d n g " g p c p , p f c " d Ã { Ã m " d k t " ± g k v n k n k m  
m e t c m v g t k u v k m n g t k " p g f g p k { n g . " w " c p f c " o g x  
w { i w n c o c n c t f c . " o w m c x g o g v . " u c k r j o v e k " { x c g ± " ± f c w { n w c  
c t v , m " i g t k n o g n g t . " u v c p f c t v " d Ã m o g " v g u v n g t  
v g u v n g t . " { g t " f g k v k t o g " m q p v t q n n Ã " { Ã m n g c

g m k r o c p " i g t g m v k t k t 0 " C { t , e C r i b n i k w g g ' u f v K u Q i p \* w 4 2 3 4  
c t v , m " i g t k n o g n g t k " v c p , o n c o c m " k ± k p " c n v g t p  
g k n o g " d g v q p " g n g o c p n c t , p , p " u g , t t c k f n c k p n i " v k e n n k x k n  
m w n n c p c t c m " ± c v n c m " ± g m e i g g " t d k g v k o r i p l i w l d a w k t m e y i n k f g g  
c o c ± n c o c m v c f , t 0 "

O g u m g p c u " x g o " p f k p t 0 " , \* 4 2 1 3 5 w w " ± c n , o c f c "  
betonun gerilme-± c v n c m " c ± , m n , , " k n k m k u k " d g n k t n g p  
Ã | g t k p f g " { c r , n c p " Ã ± " p q m v c " d e n e y s e h v e g l e r f g p g {  
m w n n c p , n c t c m " i g t k n o g p k p " u c r v c p o c u , " k ± k p "  
gerilme-± c v n c m " c ± , m n , , " k n k m k n g t k . " T K N G O " v g  
u q p t c u , " f c x t c p , " k n g " m c t , n c v , n , o , v  
i g t k n o g n g t k p k p " d g n k t n g p o g u k " k ± k p " f q t w " { 3

U w u g v { q " x g " f u k h 0 " m \* 4 2 3 5 e n v , p f c " v g u v " g f k  
\* U H T E + " r c p g n n g t k p " f c x t c p , , p , p " ¾ p i ¾ t Ã n o g  
f q t w n w w p w ± k p ç u q p n o ç m n g o c p n c t " \* U G + " ± c n ,  
gerilme-u g t v n g o g - { w o w g t d k n " o g x - g w o w d c u a , c p " ± f c x t c p ,  
f g g t n g p f k t k n k t " x g " F k u v w t d g f " U v t g u u " H k g r  
o q f g n n g t k " m w n n c p , n c t c m " , { c , m , o n , c p " , v 0 j ' d U k G p " n e g p t  
o g x e w v " m w t w e w " o q f g n n g t k p " i g n g p g m u g n " d g v q p  
u k o Ã n g " g f g d k n o g u k p g " t c o g p . " o q f g n n g t k p " U  
m e r c u k v g u k p k " c d c t v v , , p , " i ¾ u v g t o g m v g f k t 0 "

C d t k u j c o d (2013) p k p " f k c n , o c u , p f c . " ± g n k m "  
m g p f k n k k p f g p " { g t n g g p " d g v q p " \* U H T U E E + " r c  
f c , n , o , " x g " { ¾ p g n k o k p k p " g v m k u k " k p e g n g p o  
u k n k p f k t k m " ¾ t p g m n g t g . " q n k l e p v f d u f r o p t w p k " { ç p g w p w  
Ã | g t k p f g m k " g v m k u k p k " f g g t n g p f k t o g m " k ± k p "  
± , m c t , n o , v , t 0 " ¥ c v n c o c " u q p t c u , " f c x t c p , "  
± g m o g " v g u v k " k n g " f g g t n g p f d k n g m " o k n y k e p " D g p  
{ ¾ p Ã p g " f k m " c n , p c p " ¾ t p g m n g t g " i ¾ t g . " ± c v n c o  
{ Ã m u g m " ± , m o , v , t 0

O q p q v q p k m " { Ã m n g o g { g " o c t w | " m e n c p " U H T E " r  
± c n , o c n e t " { c r , n o c u , p c " t Ã c u g o n g " p x f { 4 p H T Ã E u " g m k t  
{ Ã m n g o g " c n v , p f c m k " f c x t c p , n e t , " j c m m , p f c  
C i j p k c g { ø p , p " { c r v , , " { Ã m u g m " n k u c p u " v g | k p  
g f k n g p " f q m w | " U H T E " m k t k " ¾ t p g k " Ã | c g t k p f p ,  
u q p w ± n e t , " u w p w n o c m v c f , t 0 " D w " c t c v , t o c " r  
f c x t c p , n e t " Ã | g t k p f g m k " g v m k u k p k " c t c v , t o  
c n c d k n o g " { g v g p g k p k " k p e g n g o g m v k t o 0 , " p F , g p p . g " { u  
i g n k v k t k n o k " j c u e t " v q n g t c p u , " x g " r k m " u q p t  
k { k n g v k t o g n g t " u c n c f , , p , " i ¾ u v g t o g m v g f k t  
v c m x k { g p k p " c | c n v , n o c u , p c " k | k p n ' c x l g k t n o g g e n g " k p  
i ¾ u v g t o g m v g f k t

U c n g j k c p " x p g k " p f " k { c 0 r " ø \* , 4 2 " 3 c f , m f g p c w " n ± α n , " d c a f k v  
m e t g " r c p f g g m k p t " o c Ã m n q p " v g r m k u k " Ã | g t k p g " U H T E  
g v m k u k p k " f g g t n g p f k t o g m " k ± k p " , { t c 0 " , M c t p g " d r k α p  
Ã | g t k p f g " { c r , n c p " v g u v v g p " u q p t c " p Ã o g t k m " d  
Ã | g t k p f g " g n f g " g f k n g p " p Ã o g t k m " o q f g n " k n g " r c

K u n c o " x g " . f ' k ± g 0 n " k \* m 4 2 n 3 k 6 + " m e v m , n , " m k e k k p " r  
u q p n w " g n g o c p n e t " o g v q f w " k n g " c t c v , t o , " x  
' 5 2 ø n e t f c p " ' 3 9 2 ø g " c t v v , , " i ¾ t Ã n o Ã v Ã t 0

C d t k u j c o d c k 2 0 1 5 x g ð n f , k o ± u , v p f c m n , " ± g n k m " n k  
m g p f k n k k p f g p " { g t n g g p " d g v q p w p " w | w p " x c f  
m e r u c o n , " d k t " f g p g { u g n " r t q i t c o , p " u q p w ± n e t  
± c v n c m " c ± o c " c r u 0 3 x v k 0 . 5 g m m k , p y k u p a n ' a n \* g e r i l m e s e v i y e s i n i n , l i f  
q t { c p v c u { q p w p w p " l " f k u r g t u k { q p w p w p " x g " f ¾ m  
g k n o g " u Ã t Ã p o g " f c x t c p , , " Ã | g t k p f g m k " g v  
h g p q o g p k p k p " m e n , p v , " g k n o g " f c { c p , o , " Ã | g t k  
o q p q v q p k m " v g u x ? " f 2 0 7 { " c r a " n u o g t k u k p 0 k p y . " f c j c " f Ã  
c ± , m n , , " q n c p " u g t k n g t g " m , { c u n c " f c j c " { Ã m u  
C { t , e c . " U H T U E E ) p k p " u Ã p o g " r g t h q t o c p u , . " f ¾ r  
d i k m e v g " c n e t c m " ± , m e t , n c p " r t k | o c v k m " p w o w p g n

Mk o " x g " f d k p " { 4 2 3 7 + " q n f w w " ± c n , o c f c . " c  
± g n k m " n k h " v c m x k { g n k " d g v q p n c t , p " u v c v k m " o g  
m c t , n u , " v x g " , f i g c g t n g p f k t k n o g u k " { c r , n o , v , t  
\* 3 + " C o q t h " o g v c n k m " n k h " v c m x k { g n k " d g v q p . " m  
u q p w e w " c m , m c p n , , p , p " ¾ p g o n k " d k t " m , u o , p ,  
q t c p p , . " k f ± k j c " h c | n c " u c { , f c " n k h k p " q n o c u , " x g "  
f q n c { , " m c p e c n , " ± g n k m " n k h v g p " f c j c " d Ñ { Ñ m " d  
D Ñ m Ñ n o g " o w m c x g o g v k " c ± , u , p f c p . " c o q t h " o g v c r  
takviyg n k " d g v q p f c p " f c j c " d Ñ { Ñ m " d k t " d Ñ m Ñ n o g " o  
g u p g m n k m " u g t i k n g t 0 " \* 5 + " H k d g t " g m n k p k p . " o g  
Ñ | g t k p f g m k " g v m k n g t k " f g " i ¾ | n g p o k v k t 0 " ¥ g n k  
betop c " i ¾ t g " f c j c " d Ñ { Ñ m " d k t " m , t , n o c " g p g t l k u k  
v c m x k { g n k " d g v q p w p " f c t d g { g " p g f g p " q n c p " ± c v r  
\* 6 + " D w " u q p w ± n c t c " f c { c p c t c m . " c o q t h " o g v c n  
malzemelg t " x g " { c r , n c t , p f c . " { c r , u c n " o c n | g o g  
m w n n c p , n c d k n g e g k " u q p w e w p c " x c t , n o , v , t 0

D g v q p c t o g " { c r , n c t , p " o q f g n n g p o g u k " C d e s  
Michal ve Andrze (2015) ± c n , o c n d c c t s , w p u f " c r t q i t c o , p f r e " w { i w  
j c u c t n , " r n c u v k u k v g " o q f g n E k F p R k + p " n r \* w E n q n p c e p v , g n t o g c " u F ,  
x g t o k v k t 0 " E F R ) p k p " d c | , " r c t c o g v t g n g t k " w {  
d g n k t n g { k e k f k t 0 " D w " r c t c o g v t g n " g f t Ñ | n w p o r k c p t f g ,  
dilatc u { q p " c ± , u , . " c m , " r q v c p u k { g n k " f , o g t m g |  
i g t k n o g u k p k p " d c n c p i , ± " v g m " g m u g p n k " d c u , p =  
d g v q p w p " w { i w p " d k t " m , t , n o c " g p g t l k u k p k p " v c  
n w o w p g u k p k p " v g m " g m u g p n k " x g " ± k h v " g m u g p n k " u  
u c { , u c n " u k o Ñ n c u { q p n c t " { c r , n o , v , t 0 " U q p w ±  
m c t , n c v , t o c f c p " u q p t c " { w m c t , f c " d d g n k t v k r  
d g n k t n g p o k v k t 0

D g v q p c " ± g n k m " n k h n g t k p " g m n g p o g u k " k n g " ¾ |  
J c h k h " d g v q p " m w n n c p o c m . " g m " { Ñ m n g t f g " c | c n o c  
d g v q p . " o g x e w v " { c r , n c t , p " { g p k n g p q p ù k ; m g { o  
k ± k p " x k d t c v ¾ t K " s n d w c n n n " c x p g , d o f k , k p " , 0 " ¾ p 4 n 2 g 3 t 7 0 - e | n f w w " ± c

± g n k m " g n { c h " k ± g t k k p f g m k " f g k k m n k k p . " ±  
m g p f k n k k p f g p " { g t n g g p " d g v q p w p ü k \* U J N U E E + v ,  
c o c ± n c o c m v c f , t 0 " V c | g " d g v q p " m c t , , o , p , p " k  
{ c r , n o , v , t 0 " U g t v n g v k t k n o k " d g v q p w p " f c j  
o w m c x g o g v k . " g n c u v k m k { g v " o q f Ñ n Ñ " Taxe g v ě g k n o  
u g t v n g v k t k n o k " ¾ | g n n k m n g t k p f g m k " f g k k o  
U J N U E E " m c t , , o , " \* ' " 2 . ' " 2 0 7 . ' " 2 0 9 7 . ' " 3 " x g  
n k h " k ± g t k k ' " 3 " x g { c " f c j c " h c | n c " çin e k i p " U J N U  
q n f w w p w " i ¾ u v g t o g m v g f k t 0 " G u p g m n k m " o q f Ñ  
o w m c x g o g v k p f g " { c m n c , m ' " 3 4 " c | c n o c . " { c t ,  
o w m c x g o g v k p f g " u , t c u , { n c ' " 5 9 " x g ' " 3 3 2 " c t v ,  
m c n , t 0

C d t k u j c o d c h (2016) o g p k ± f c k n , 0 " o c n c t , p f c . " ± g n k m  
m g p f k n k k p f g p " { g t n g g p " d g v q p w p " n c o k p g t " { c  
f g p g { u g n " x g " u c { , u c n " d k t " { c m n c , o " u w p w n o  
r t k | o c v k m " p w o w p g n g t o " g Ñ | v g g t u k v p n f g g t " k f " ¾ t c v r " , p n q f m v 0 c " n ,  
f c j c " u q p t c " H G O " ± g t ± g x g u k " c n v , p f c " o q f g n n g  
n k h n g t " q n o c m " Ñ | g t g " k m k " h c | n , " d k t " o c n | g o g '  
q n o c { c p " o c n | g o g " f c x t c p f g n k . " m 5 h h u o g a t g f m ě u  
h k d g t " i Ñ ± n g p f k t o g " o g m c p k | o c n c t , " f g - p g { u g n  
o g m c p k m " f c x t c p , " m w t c n n c t , " k n g " o q f g n n g p o l

Pikus (2016), ± g n k m " n k h n k " d g v q p " k ± k p " o g x e w v "  
tahminleri parc o g v t g n g t k p g " i g p g n " d k t " d c m , " u w p c t 0  
x k u m q | k v g " i k d k " u v c p f c t v " d g v q p " k n g p g d k n k t  
k ± k p " m w n n c p , n c o c { c e c , p , " i ¾ u v g t o g m v g f k t 0

O q t c f k . (2016) o f p k v " ± c n , o d f k d . " m f q g o a q p v k g y " m  
v c d n k { g u k p f g " g p k p g " u , e l p a f t a k v i y e p i f b e t o n (S F R C) " r t g  
n g x j c n c t , p " f c x t c p , , p , " c t c v , t , n o c m v c f , t  
{ Ñ m n g o g u k " c n v , p f c " v g u v " g f k n o k c v k v 0 t 0 ¾ m ğ b ğ  
j c t k e k " u ¾ m Ñ n g d k n k t " m c { , n c t " x g " ± c r t c | " f  
± w d w m n c t , p , p " m q p h k i Ñ t c u { q p w " x g " q t c p , . " d g v  
u , p , t n c o c " u k u v g o k p k p " v k r k " \* ± k e m l e r d i % 0 , 5 i g t f k t

f q | c l n , " ± g n k m " n k h n g t k p . " ± g n k m " ± w d w m " k ± g t c  
n g x j c n c t , p , p " { Ñ m " v c , o c " m e r c u k v g u k p k " ¾ p g o  
u k u v g o k p " g p g t l k " d c | n , " u Ñ p , g m n , k t 0 k " " C { t t v , , e t c c . d " k i  
v c m x k { g " ± w d w m n c t , p , p " d k t " m , u o , p , p " { c r , u c  
m , u , v n c p o , " U H T E 1 T E " r t g m c u v " i Ñ x g t v g " n g x  
k { k n g v k t g d k n g e g k " i ¾ u v g t k n o k v k t 0

Y w " x g (2016) p k a p o , " q n f w w " ± c n , o c f c . " h c t m n  
\* X h " ? " 2 . " ' " 3 . " ' " 4 " x g " ' " 5 + " Ñ ± " h c t m n , - " g m k n  
g p f + " w n v t c " { Ñ m u g m " r g t h q t o c p u n , " d g v q p w p " \*  
c t c v , t , n o , p v , " Ñ l i " U k p g v t ± k c k p k p " t x g " f g h q t o g "  
W J R E ) p k p " c m , m e p n , , p , " m e f g o g n k " q n c t c m " c  
g k n o g " f c x t c p , , " Ñ | g t k p f g " ¾ p g o n k " g v m k n g t  
W J R E ) p k p " g k n o g " k p Ñ k Ñ " m i " c ± r e o v c n " c g n " t o k w m k p x g o g v k "  
Ñ | g t k p f g " u , p , t n , " g v m k { g " u c j k r " q n f w w . " c p  
u q p w e w p c " w n c , n o , v , t 0

Mousavi (2017). " ± k o g p v q p w p " u k n k u " f w o c p , " k n g " n  
x g " ÷ j g m k , m " n , " d c u k v " o g u p g v n k " r c p g n n g t k p " g k  
c t c v , t o , v , t 0 " ¥ c n , o c " p g v k e g u k p f g . " ± g n k m  
c t v , t f , , " u q p w e w p c " w n c , n o , v , t 0

P g j o g " x g " f k ± 0 g " n k 4 n 2 3 n 9 k + h " p v f c g m p x " k { g n k g ñ g g p p " f  
r c p g n n g t k p " h c t m n , " n k h " f q | c l , " x g " f q p c v , "  
o g m e p k m " ¾ | g n n k m n g t k p k " k p e g n g o g m " k u v g o k n g  
c t v o c u , { n c " m g p f k n k k p f g p " { c g n t f n , g , g " p c p d e g c v m " p w  
c t v o c u ÷ f { g m c q " t o Ñ m { q p " m e r c u k v g u k p k p " c t v v , , "

D g v q p w p " ± g n k m " n k h n g t n g " v c m x k { g " g f k n o g  
f c { c p , o , . " g p g t l k " g o k n k o k " x g " ± g m o g " n f c { c p ,  
± c n , o c n c t n c " m e p , v n c p o , v , t 0 " U q p " { , n n c t f  
u r k t c n " i g q o g v t k u k p k p " u Ñ p g m n k m . " ± c v n c m " m q p  
g o k n k o k " c ± , u , p f c p " f k g t " n k h " v k c p e t k p g ñ w ¾ x  
d Ñ m Ñ o n Ñ " ± g n k m " g n { c h n c t , p " ± g m o g " f c x t c p , , '  
D w p w p n c " d k t n k m v g . " n k v g t c v Ñ t f g m k " u r k t c n " n k

{ c r , n o c o , v , (2007) } p w p " x g ' t b c q " q n e l i k w i f i n w e t o n c n , o c  
o c v t k u v g p " u r k t c n " i g q o g v t k u k " k n g " ± g m o g " f  
q n c t c m . " m c p e c n , " w ± n w " ± g n k m " n k h n g t " f g " j c |  
G k o " w | w p n w w . " i ¾ o o g " w | w p n w w e l l i k l e ' s a h i q d k p " ± c  
q n c p " u r k t c n " n k h n g t " h c t m n , " q t c p n c t f c " d g v c  
f c { c p c t c m . " { g t n g v k t o g " w | w p n w w . " ± g m o g " q t  
c t c v , t , n o , v , t 0 " V g u v " u q p w ± n c t r i n i m , v ø " c p c n  
{ c r , n c t , p , p " r g t h q t o c p u , p , " f c j c " f c " c t v v , t  
d k t n g v k t k n o g u k " j k d t k v " ± g n k m " n k h " v c m x k { g  
n c d q t c v w x c t " v g u v n g t k . " d w " v g m , p t k , r k ø c " u d g r f ø p  
g v m k p n k k p k " m c p , v n c o , v , t 0

O q t c f k . (2017) { f k o , " q n f w w " ± c n , o c f c . " g p k  
c f g v . " { c t , " { c t , { c " ¾ n ± g m n g p o k . " r c t ± c n c p c  
p q m v c u , p c " w { i w n c p c p " u v c v k m " x g " f ¾ p i Ñ u g n " {  
i g n g p g m u g n " v c , m x x k g { " g m ' q f p q w p o c w " , k " n q g t " c ± p g n k m " n k h " f c  
T E " r n c m e n c t , p , p " { Ñ m " v c , o c " m e r c u k v g u k " x  
k p e g n g p o k v k t 0

M g p f k n k k p f g p " { g t n g g p " d g v q p w p " w { i w n c p  
d w n o w v w t 0 " D w p w p a c ü d k i g k g n g k m w g ' n c d q t c v w x  
o c n | g o g " r c t c o g v t g n g t k " j c m m , p f c " d k n i k " g m  
{ c r , n c t , p , p " x g " f q t w u c n " q n o c { c p " u q p n w " g  
d k p c n c t , p " v c u c t , o p , , p t f 0 c " " U w q e t j . (2017) r c c ' r x o g c " " f ù k q p w ± n  
± c n , o c f c . " f q t w u c n " q n o c { c p " u q p n w " g n g o c p n  
{ g t n g g p " u g ± k n o k " d g v q p " m k t k n g t k p " o g m c p  
u q p w ± n c t , p , " u w p w n o g c o n g v . c " f k , m k 0 " " v k p r e " g x g g ' p Ñ p " j c a  
i Ñ ± n g p f k t k n o k " { Ñ m u g m " r g t h q t o c p u n , " d k t " d g

F g t g " x g " (2017) ø p ø p ñ v c r o , " q n f w w " ± c n , o c f c  
d g v q p n c t , p " f q t w u c n " q n o c { c p " u q p n w " g n g o c p  
modelini g v m k n g { g p " ± g k v n k " r c t c o g v t g n g t " v c t v ,  
o q f g n n g p o g u k p f g " d g v q p " j c u c t n , " r n c u v k u k v g  
d k t n k m v g " C D C S W U " { c | , n , o " r c m g v k p k p " m w n n c p  
g m k n f g " è m w ñ ñ g p q p " o c n | g o g " k ± k p " d - g e n i n i m p ± " x g "

knk mkuk " xg " j c u c t " r c t c o g v t g " g t k n g t k " ¾ p g t  
r g t h q t o c p u , . " d e u k v " f q t w u c n " q n o c { c p " d k t " o

D g v q p c t o g " r g t f g<sup>¾</sup> " f w k p f g ð t d , w p n " w p a p " d h g v q p  
f c { c p , o , " u c { g u k p f g " f Ñ g { " x g " { c v c { " { Ñ m n g t  
c n v , p f c m k " r n c u v k m " m t k v k m " d ¾ n i g f g " { Ñ m u g m  
\* U H T J U E + " f ¾ m Ñ n o g u k { n g " r g t f g p ' , p w x k t k n g , p g  
d g m n g p o g m v g f ð t 0 \* 4 N ¾ : c + x o g p , k f " k q n f w w " ± c n , o c f  
d g n k t n g p o k " U H T J U E " o g m c p k m " ¾ | g n n k m n g t k p g  
r g t f g " f w x c t " i g n k v k t k n o k " x g " ± g n k m " n k h " j  
f w x c t f , q p , t p w u c n " q n o c { c p " f c x t c p , , " Ñ | g t k p f g n  
J U E . " u , t c u , { n c " c n v " x g " Ñ u v " { c t , n c t c " f ¾ m Ñ n  
± g n k m " r t q h k n " { g t n g v k t k n o k v k t 0 " 3 1 4 " ¾ n ±  
kompozit perde dux c t , " f Ñ Ñ m v f g x k m t " n l g ' u f a t g t g " v c d k " v w v  
f ¾ p i Ñ u g n " q n c t c m " c t v c p " { c p c n " { Ñ m n g t " x g " c t  
{ Ñ m " c n v , p f c " v g u v " g f k n o k v k t 0 " ' " 2 . " ' " 3 0 2 . "  
olan kompoz k v " g n g o c p n c t , p " u k u o k m " r g t h q t o c p u , " Ñ  
U q p w ± n c t . " U H T J U E " m q o r q | k v " r g t f g " f w x c t , p "  
m q { o w v w t 0 " U H T J U E " m q o r q | k v " p w o w p g u k p k p " f  
r g t f g " f w x c t , p u n k p f g p m d , c j ' c x g " Ñ ± g n k m " n k h " ± k o  
¾ p n g f k k p f g p " g k n o g " f g h q t o c u { q p w p w p " m c f g  
¥ c v n c m " x g " j c u c t " u Ñ t g e k " g t v g n g p o k " x g " c t v c  
c | c n v , n o , v , t ð K t C " { n k k ' c j ' c é k ð 2 ) n k p , " m w n n c p ,  
{ g v g p g k " ¾ p g o n k " ¾ n ± Ñ f g " i g n k o k v k t 0

D g v q p f c " v c m x k { g " q n c t c m " n k h n k " r q n k o g t "  
± g m o g " o w m c x g o g v k . " m q t q | { q p " f k t g p e k " x g " j c  
f k (201: p k p " { c r v , , " ± c n , o c f c . " H T R " m w o c " v c  
d g v q p " \* W J R E + " r c p g n n g t k p " g k n o g " f c x t c p , n c  
u w p w n o c m v c f , t 0 " E c o " n k h " v c m x k { g n k " r q n k o g t  
\* E H T R + " m w a g p o k t v k p ð g I H T R " x g " E H T R " m w o c n c  
j c t ± " x g " o k m t q " ± g n k m " n k h " k ± g t g p " W J R E ) p k  
f g g t n g p f k t k n o k v k t 0 " H T R " m w o c , " x g " ± k o g p v  
itme-± g m o g " v g u v n g t k " c m m w n t k d p g , " n c g t f c k m " o k m c v t k t 0 "



{ c r , n c p f , t o c n c t , p c " u c j k r " r c p g n n g t k p " g  
f g g t n g p f k t k n o k v k t 0 " I H T R " x g { c " E H T R " m w o c  
d ã m ã n o g " ¾ | g n n k m n g t k p k " c t v v , t o p , " r . c " p c g p n e n c g m " " { k  
d ã m ã n o g " f c { c p , o , p f c " j g t j c p i k " d k t " c t v , c  
W J R E " r c p g n n g t k p " g k n o g " f c x t c p , , p , " c p n c o c  
{ c r , n , t 0 " " p g t k n g p " m w o c " v c m x k { g n k è W J R E " r  
m e n , r n c o c " u k u v g o k p k p " i g n k v k t k n o g u k " k ± k p  
r q v c p u k { g n " q n c t c m " c t v v , t , n o , " ± c v n c m " f k t g  
{ c r , o , p f c " m w n n c p , n c d k n k t 0

C n u c k h. "(2018), "asfalt betonu veya polimer g " d c n , " m c w ± w m " {  
c n v g t p c v k h " q n c t c m " g u p g m " d g v q p " m e r n c o c n c t  
v c m x k { g n k " m c w ± w m n w " d g v q p " \* U H T T w E + " ã | g t k p f  
± c n , o c p , p " v g o g n " c o c e , . " ± f g ¾ p k ã n " v ã t h ã n g o t ã p " " n \* k  
c v , m " n c u v t r k h k m g t w g p h h ç w ± w m n c p o , " d g v q p w p " o  
g v m k u k p k " c t c v , t o c m v , t 0 " Q p " h c t m n , " m c t , ,  
k ± g t k m n g t k f k t 0 " U q p w ± n c t . " T w E : " m e n t w ± w m h c k t ±,  
p g f g p k { n g " g k n o g " f c { c p , o , " m c { d , p , " \* i g n g p g  
¾ p g o n k " ¾ n ± ã f g " c | c n v v , , p , " i ¾ u v g t o g m v g f k t  
d ã m ã n o g " o w m c x g o g v k p k p " i g n k o g u n k p e k p i k u c n c {  
u q p t c u , " g p g t l k " g o k n k o k p k " c t v , t c d k n k t . " d ¾  
c n v g t p c v k h " { c r , " o c n | g o g u k " j c n k p g " i g v k t k t 0

U w p " x 0 g " " \* f 4 k 2 3 { : c r o p k p " q n f w w " ± c n , o c f c . " {  
u , m , v , t o c " { ã m ã p g " o c n u n ( S F R C ) t e k n e k s e n l i m e l a n i k k m " n k h  
¾ | g n n k m n g t k " j c m m , p f c " f g p g { u g n " d k t " ± c n , o  
fraksiyonunun (% 0.0, % 0.75, % 1.5, % 3.0, % 4.5 ve % 6.0) SFRC numuneleri  
Ã t g v k n f k " x g " 9 7 " o o " ± c r , p f c " d k t " d B n ã p o ã  
m w n n c p , n c t c m " v g u v " g f k n o k v k t 0 " U J R D ) p k p " k n  
¾ t p g m n g t k p f g " u c d k v " i g t k n o g " q t c p , p , p " m q t w  
c t c v , t , n , t 0 " G n f - g k g k h g g h k k p f g k k n a r a k , g t k g ö g  
f k p c o k m " i g t k n o g " c t v , " h c m v ¾ t ã . " h k d g t " i ã  
g o k n k o k " j g o " i g t k n o g " j , | , " j g o " f g " h k d g t " j c e  
g v m k u k " x g " f ã | " d g v q p " x g " U H T E ) p k p " f k p c o k m

j c mm, p f c " d k t " h k m k t " x g t k t 0 " g m k n " f g k v k t c  
o g m c p k | o c n c t " v e t v , , n o c m v c f , t 0

G p f Ñ u v t k { g n " c v , m n c t , p " u Ñ t f Ñ t Ñ n g d k n k t " d  
o c n | g o g n g t k p " f Ñ Ñ m " o c n k f g o n k c q n p n u t p p c p ¾  
m c | c p f , t , n o c u , p f c p " x g " c { t , e c " d g v q p w p " r g t l  
i ¾ t o Ñ v Ñ t 0 " O q j c o 0 " c \* f 4 2 3 u g d p k p q g f w k w " ± c n ,  
o g v c n " m q o r q | k v " Ñ t g v k o k p f g " r c c v n , o m " { o c g v , c " n { k c | n g , " v  
\* R Q H C + " w { i w n c p c d k n k t n k k . " f c t d g " f c { c p , o ,  
k p e g n g p o k v k t 0 " Y O R " n k h n g t k " k ± g t g p " ' 2 " k n c  
4 2 " d g v q p " m c t , , o , " u , t c f c p " R q t v R Q H C ) p k p g p v  
Q R E ) { k " k m c o g " g v v k k " c { p , " n k h " k ± g t k k p g "  
{ c r , n o , v , t 0 " Y O R " n k h n g t k p k p " x g " R Q H C ) p , p "  
f g g t n g t k p k " c | c n v o , v , t 0 " Y O R " n k h n g t k p k p "  
b c u , p ± " f c { c p , o , p , " c | c n v o , v , t 0 " D w p w p n c " d k  
d c | n , " m c t , , o n c t . " Q R E " d c | n , " m c t , , o n c t f c p  
g v o k n g t f k t 0 " Y O R " n k h n g t k " x g " R Q H C " c t c u , p f  
f c { c , p , " o g k n o g " x g " c { t , n o c " ± g m o g " f c { c p , o n c t  
m e r c u k v g u k " x g " d g v q p " u Ñ p g m n k k " i g n k v k t k n  
Ñ t g v k o k p f g " Y O R " n k h n g t k p k p " x g " R Q H C ) p , p " m w  
u y g u l a m a l a r d a k w n n c p , n c d k n g e g m " d g v q p " d k n g g p n g t k  
¾ | g n n k m n g t k p k " c t v v , t o c " r q v c p u k { g n k " q n f w v

D g v q p " f Ñ Ñ m " m , t , n o c " o w m c x g o g v k " x g " ± g m  
{ Ñ m u g m " m , t , n i c p n , c " u c j c k p r " v r k g t 0 h " q D w o " c p Ñ t . "" v d c g v  
n k h n g t k p " g m n g p o g u k " k n g " i g n k v k t k n g d k n k t c  
r g t h q t o c p u , " p g f g p k { n g " u q p " { , n n c t f c " r q r Ñ n g  
o c m t q " ± c v n c m " { c { , n , o , p f c m k t o s k o p i k i s e v i y e g . " o  
± , m o c u , p , p " ¾ p n g p o g u k . " u Ñ p g m n k m v g m k " k { k n g  
o w m c x g o g v " x g " { Ñ m u g m " v q m n w m " d w n w p o c m v c f , t c  
± g n k m " n k h n g t k p " g m n g p o g u k p k p . " Ñ m " d g v q p n k f i n n  
Ñ | g t k p f g m k " g v c n d k d u c t x g v f c h , 0 0 ¾ 4 2 3 t , p f c . " Ñ ±  
q t c p , { n c " \* 2 0 4 7 . " 2 0 5 7 " x g " 2 0 6 7 + " Ñ ± " w | w p n w m v  
o o + " m c p e c n , " w ± n w " n k h n g t " m w x n g " c ' p " o 3 , 0 7 " x q n " o ± c g m " k

Ã± " j c e k o " h t c m u k { q p w " k n g " k n c x g " g f k n o k v k t  
h c t m n , " u w " x g " ± k o g p v q " q t c p n c t , p c " u c j k r  
o w m c x g o g v k p f g<sup>4</sup>7()cnnknne" d, km "" c3t2v , n c " xigde f q t w f  
{ c m n c -6 9h" ÷ 5 3 , n c " d g v q p w p " o g m c p k m " ¾ | g n n k n  
q n f w w p w " i ¾ u v g t o k v k t 0

X g p m c v g u j y c t c p p " k x p g " { f c k v 0 " m ñ 4 2 3 : " ± c n , o c f c  
f g k v k t o g " g t k n g t k p g " m c t , " i ã g v t ã k n n g k p o " k 8 " ; g " n ± f g g  
g n { c h " v c m x k { g n k " d g v q p " \* U H T E + " r t k | o c n c t " ã |  
u w p w n o c m v c f , t 0 " ð h k ÷ g t " f k ÷ g t " h c k ' h 4 2 ' q m i c p ö x g " ±  
k ± g t g p " U H T E " r t k | o c n c t , p , p . " k n m " ± c v n c m v c p  
u g t i k n g f k k " d w n w p o w v w t 0 "

D q t i g u . \* 4 2 3 f { k c o r p o k , p "" q n f w w " ± c n , o c f c . " d c  
(double edge wedge u r n k v v k p i + " v g u v k " m w n n c p c t c m " f ã ã  
v c m x k { g n k " m q o r q | k v v g p " f g " n k h " k ± g t k k p k " f g k v k t g t  
f c x t c p , , " c t c v , t , n o , v , t 0 " F g p g { u g n " ± c n ,  
m q p w { c " q f c v n g n u e v p " o { g t v " , f g " k v k t o g " q t c p , p , p " g  
H T E ) n g t k p " q t v q v t q r k u k 0 " F G Y U " v g u v k " k ± k p " d  
d ã { ã m " d k t " { g t " f g k v k t o g " j , | , . " q t v c n c o c "  
i g p k " d k t " c | J c g n t o " c k " m k c " H h T c E o ) , p k v p , " t \* 0 U H T E " x g " O U H T  
F G Y U " v g u v " q t { c p v c u { q p w " f g k v k t k n g t g m " c ±  
m q o r q | k v v g p " f g " n k h " k ± g t k k p k " f g k v k t g t  
g f g d k n o k v k t 0 " ¥ g m " k m ñ o t k d h ñ . v " c g n p x " k { ã u n k g ñ " i g ã g n  
d c m , o , p f c p " f c j c " g v m k n k " d k t " u q p w ± " x g t o k v  
m w n n c p , n o c u , . " ¾ | g n n k m n g " p w o w p g p k p " ± c v n c  
m e r c u k v g n g t k " p g f g p k { n g c . "" u f c p j t c " u c , | " " r u g c t h , q n t o , c  
m q { o w v w t 0

G p f ã u v t k " k p c c v " u g m v ¾ t ã p f g " i g n g p g m u g n  
± , m c p " ± g x t g u g n " g v m k p k p " c | c n v , n o c u , " k j v k { c  
m q o r q | k v " o c n | g o g n g t g " f c g { v o p k c p ' k t c 0 ' c U ð , p t e j c g ñ  
(2019) ø p k p r o , " q n f w w " ± c n , o c f c . " i g n g p g m u g n  
k p c " g f k n g p " r c p g n n g t k p " h k | k m u g n " x g " o g m c p k  
x g " { ã | g { " k n g o n g t k p k p " g v m k l a r , k b i t k i s e l p i d e r i k | " g f k

{ Ã | g { k p g " d k t " k n g o " w { i w n c p f , , p f c " m t k u v c  
c t v v , , p , " m e p , v n c o c m v c f , t 0 " D w " e k o m p o z i t i n k m e u {  
r c p g n n g t k p " k o g " { Ã | f g u k p k p k o m p o z i t i n h i z m e t o c u , p o  
¾ o t Ã " d q { w p e c " r g t h q t o c p u , p , " c t v v , t , t 0 " H k |  
o r y a n t a s y o n u n u n b i y o - m q o r q | k v n g t k p " ¾ | g n n k m n g t k " Ã | g t k  
{ ¾ p n Ã " n k h n g t n g " { c r , n c p " r c p g j n c n " g d Ã { f Ã n j " c d " q { Ã w n  
m e t c t n , n , m " x g " f c j c " f Ã Ã m " g o o g " m e r c u k v g u k  
d k t " r n c | o c " k n g o k " i g t ± g m n g v k t k n k t m g p . "  
m e n f , , p f c " \* ± g m o g . " u , m , v , t o c + " o g m e p k m "  
f g g t n g t k p k p " c t v v , , p , " i ¾ u v g t o k v k t 0

H g p i " α " g \* 4 2 3 c ± o p k p q n f w w " ± c n , o c f c . " w n  
j k d t k v " n k h " v c m x k { g n k " ± H F R C C ) p p e n e t r a s y o n u d r e m e n , " m q o  
r q v c p u k { g n k " ' 4 " n k h " k ± g t k | k n p g f t g k " k k p ± l g m . g " p ± o g k k v  
m e t , , o n c t , p c " J u H T j E k E r " " o 3 c 4 n " | i g t o w g r u " k v J g R " m e t , " f Ã |  
\* R E E + " m w n n c p , n o , v , t 0 " D c u , p ± " f c { c p , o , p , "  
n k h v g p " f c j c " k { k " r g t h q t o c p u g ' i ¾ u v g t Ã f p k n Ã k m p ' k d "  
f c { c p , o , p , " d g n k t n g o g m " k ± k p " v g m " g m u g p n k " v  
U H P - J H T E E " j g f g h k " k ± k p " r g p g v t c u { q p " v g u v n g t  
r g t h q t o c p u , " r g p g v t c u { q p " f g t k p n k t k n ð ð F Q R k t ' 0  
F g p g { u g n " u q p w ± n c t . " ± g n k m " n k h " v c m x k { g n k "  
i g n k o g " r q v c p u k { g n k p k p . " r q n k r t q r k n g p " n k h  
m q o r q | k v k p k p m k p g " i ¾ t g " d k t c | " f c q l i p r o p i l e m g t k " i  
n k h k p " m q o d k p c u { q p w " r g p g v t c u { q p c " m e t , " r q  
r q n k x k p k n " c n m q n " n k h k p " ± k o g p v q n w " m q o r q | k v  
{ c t c v v , , " i ¾ | n g p o k v k t 0

D c d c k g 0 " x g 4 2 3 ; c ± o p k p " q n f w k w " g ± ð n v , k r d c f " c k " ± l g  
j k d t k f k | c u { q p w " k ± g t g p " d k t " f k | k " h k d g t " r c t  
\* R H T E + " x g " ± g n k m " h k d g t " v c m x k { g n k " d g v q p w p "  
g v m k u k p k " c t c v , t o c m " c o c ± n c p c m , " m v k , t t k 0 " " H f q 4 m " Ã u n  
x g " f c j c " ¾ p e g " d c j u g f k n g p " c p c " n k h " ¾ | g n n k m n g  
U H T E ) p k p " R H T E ) { g " m , { c u n c " j g t " o g m e p k m " ¾ | g n  
± g m o g " o w m c x g o g v k " U H T E ) f g p " f c j k p ' f Ã t Ã m , " t ¾ , n n ±

± q w " f w t w o f c " H T E ) p k p " o g m c p k m " ¾ | g n n k m n g t k  
d g n k t n k " d k t " g n { c h " m c t , v , t o c " q t c p n c t , p f c  
f ã ã m " o c n k { g v n k " d k t " j k d t k v " g n k u k a v e m e t i c m x k { g  
ã | g t k p f g " c x c p v c l n , " g v m k n g t k " q n f w w " i ¾ | n g p

Ribeiro ve Serna (2019) ø p , p " { c r o , " q n f w w " ± c n , o c f c  
f c { c p c p " ± g n k m " g n { c h n , " d g v q p " k ± k p " d c u k v "  
o q f g n f g " d g v q p . " C P U ð p U c " m " ã m , ã t r , j r i p c g p u " k o f r g | " g l o w n g  
d k t " g n g o c p " m w n n c p , n c t c m " o q f g n n g p o k v k t 0  
\* u r c p { c + " F w x c t , ) p , p " d k t " r c t ± c u , " q n c p " m e d  
c , t n , , " x g " u , e c m n , m " f g t k ' u k g i n c g g p k v ' n f g k h m c ã  
i g t ± g m n g v k t k n o k v k t 0 " G n f g " g f k n g p " u c { , u c  
u q p w e w p c " x c t , n o , v , t 0

L q p i x k x c v u c m w p k p g ð f k " Q ñ f \* 2 ð ; ± c n , o c f c  
\* U H T E + " r c p g n n k . " m c d { g o v c q " p k c ± k o p g " " i \* ã t + e n + g " p n f k k t k k n n o g k t  
f g p g { . " c p c n k v k m " j g u c r n c o c " x g " u c { , u c n " c p c  
d c n c p v , " v k r k . " e , x c v c " u c { , u , " x g " ± c r , p , p  
ã | g t k p f g m k " g v m k n g t g k t p k p " c j t g c t " v k m l o " c m ð t k c k , p p c " r  
m w n n c p , n c t c m " i ã ± n g p f k t k n o k " d g v q p c t o g " m k t  
O g x e w v " m c { o c " f k t g p e k " o q f g n k . " U H T E " r c p g  
c n , p f , , p f c " v g u v " x g t k n g t p g k ù g y r " t u q p w e m ð t k .  
r c p g n n g t k " m w n n c p , n c t c m " i ã ± n g p f k t k n g p " m k t  
k { k n g v k t k n f k k p k " i ¾ u v g t o g m v g f k t 0 " C { t , e  
r t q i t c o , p f c " ã ± " d q { w v n w " \* 5 D + " q n o c { l e r p " f q t v  
f g " { c r , n o , v , t 0 " F g p g { u g n " x g " c p c n k v k m " u q p  
C p c n k v k m " ± c n , o c { , " v c o c o n c o c m " k ± k p . " r c p g r  
x g " m k t k n g t k p " r g t h q t o c p u n c t , p f c m k " e k e , x c v c  
k ± k p " r c t c o g v t k m " d k t " ± c n , o c " { c r , n o , v , t  
i ã ± n g p f k t k n o k " U H T E " r c p g n n g t k p k p " f k { c i q p  
f c { c p , o , p , p " d c u k v " h q t o ã n c u { q p w p w " k ± g t g p '  
u k u v g o k p m p h g g " k n n k p f g o " m g u o g " m e v m , u , p , " v c  
f q t w n w m n c t . ¾ p g t k n o g m v g f k

O k e j g n u " x g o p k f p k " 0 c r \* 0 4 , 2 3 " 5 q n f w w " ± c n , o c f c  
d g v q p w p " \* U H T E + " ± c v n c o c " u q p t c u , " o w m c x g o g v  
Ã | g t k p f g " u g g " x g " u c { , u c n " d k t " c t c v , t o c " u w p w  
h k d g t " v k r k . " h k d g t " f q | c l , " x g " p w o w p g " d q { w v v  
f c x t c p , , " Ã | g t k p f g m k " g v m k u k " Ã | g t k p g " d k t " .  
tesv " k ± k p " ± g m o g m g n " i g g k k o g k t o g " k n k m k n g t k p  
r t q u g f Ã t Ã p Ã p " i g n k v k t k n o g u k f k t 0 " D w " c o c ± n  
f c { c n , " d k t " m , t , n o c " o q f g n k " f Ã u g j p k m b g t k n g g  
u c { , u c v n k " o d k k | t c " u q { r q p " r t q u g f Ã t Ã " k n g " w { f w t w n o w  
¾ p g t k u k p k p " { c p , " u , t c " d Ã { Ã m " ¾ n ± g m n k " r n c m c r  
Ã | g t k p f g " f g p g { u g n " c t c v , t o c " { c r , n o , v , t 0  
m q w n n c t , ; o n v m p v f x g v n g t k p k p " x g " g p g t l k " c d u  
k n m " k | n g p k o n g t k " x g t o g m v g f k t 0 " H k d g t " f q | c l  
v q r n c o " g p g t l k " c d u q t r u k { q p w p w p " c t v v ; , " i ¾ t  
d q { " q t c p , ¾ | g a j k m f i g n g p Ã | g t k p f g " f g " q n w o n w  
c f , o f c . " c t v c p " ± g m o g " i g t k n k o k " k n g " c | c n c p " i  
x c t u c { , n c t c m . " i g t k n k o f g m k " k m k " ± c v n c o c " u q p  
bir parametrik optio k | c u { q p " r t q u g f Ã t Ã " i g t ± g m n g v k t k  
u c r o c " u g x k { g n g t k p f g " f c j c " { Ã m u g m " j c u u c u k  
k n k m k p k p " f g p g { u g n " g t k n g t k p " f c j c " f q t w  
J g t " k m k u k " k ± k p p k f p g " f m g t g t n m g c p " f g k p t g k t n l o k g u u k " d g p |  
q t v c { c " ± , m c t , t " x g " h c t m n , " p w o w p g " d q { w v n c  
p w o w p g n g t n g " w t c , t m g p " f c j c " f Ã Ã m " ± g m o g "  
k n g " u q p w ± n c p c p " d k t ; . d n q { w t " g v m k u k p k " q t v c {

R ² t g | " x g " o f p k k p o r " o \* ; 4 2 ' 4 q 3 n + f w w " ± c n , o c f c . " m  
m g p f k n k k p f g p " { g t n g g p " d g v q p w p " o g m c p k m " ¾ |  
i g t k n o g " { q w p n w m " h c m v ¾ t Ã p Ã " \* M K E + . " F k l k v c  
d ¾ t v " p q m v c " g k n o g " v g u v k " c n v , p f c m k " m k t k n g  
f g g t n g t k p k " g n f g " g v o g m " k ± k p " f g g t n g p f k t k  
c ± , m n , , " { g t " f g k v k t o g u k p g " f c { - Irwin , " q n c t  
taraf , p f c p " ¾ p g t k n g p " m , t , n o c " o q f g n k " m w n n c p , n o  
g n f g " g f k n f k 0 " G n f g " g f k n g p " u q p w ± n c t . " F K E ) p  
x g " x g t k o n k " d k t " c n v g t p c v k h " q n f w w p w " i ¾ u v g t

Ng g " x g " f k p " 4 2 3 9 e . , " ± k m v " o q v c p u k { g n " \* F R E O + " q n c t c m " c f n c p f , t , n c p " ± g n k m " h k d g t " v o o w m c x g o g v k " o q f g n k " ¾ p g t k n o g m v g f k t 0 " I ¾ | " ¾ p Ñ x g " ± c v n c m n , " ± g m o g " v c q r d c , p " , Ñ | " g n t g g u . o " g d ' c m u c m , m p " n o q f w p w " w { i w p " d k t " g m k n f g " i ¾ | " ¾ p Ñ p f g " d w n n k h n g t k p " m g u o g " m e v m , u , p , " j g u c r n c o c m " k ± k p { ¾ p g n k o k p k " x g " d c " ¾ | g n n k m g g n b g p k m " w k k g m k v g " o q f g n k " \* F V H V O + " v c p , v , n o , v , t 0 " U H T E " m k t t g h g t c p u n c t f c p " v q r n c p o , " x g " ¾ p g t k n g p " F R E O F R E O ) p k p " d c u k v n g v k t k n o k " d k t " g x f g Ñ t u n k g { t q k p p k ' c | c n v c t c m " r t c v k m " w { i w n c o c n c t " k ± k p " i g n k v l

J c k f q " x g " f k p 0 { \* 4 2 3 3 , + " ± c n , o c f c . " n k v g t f g p g { u g n " x g t k { g " d c n , " q n c t c m . " ± g n k m " n k h n olmayan malzeme kurucu matematiku g n " o q f g n n g t k p k p " h q t o Ñ n c u U H T E " f ¾ g o g " x g " m k t k n g t k p " r c v n c o c " x g " f c t c c t c v , t o c m " k ± k p " u g m k | " f Ñ Ñ o n Ñ " f g l g p g t g " o c n | g o g p k p " d c u , p ± " f c x t m k p ' , o q , f p g , n . u ' k l α Ñ r k g " g g n c a r n c u v k m " x g " i g t k p k o n g " u g t v n g g p " r n c u v k u h q p m u k { q p w p w p " i g t k p k o " j , | , p , p " d k t " h q p m u x c t u c { , o n c t , p , " f k m m c v g " c n c t c m " m a t i k s a l c o " N c i o q f g n f g " m e v o c p n , " { c m n c , o f c m k " i g q o g v t k m " f J c t g m g v " f g p m n g o k p k p " | c o c p " ¾ p v ¾ i t Ñ c u { n q m ' t k ¾ ¾ t v Ñ m " P g y o c t m " d g p k o u g p o k v k t 0 " D g v q p " ± c { c m n c , t o g , " p d g ' n i k ¾ n g p o k v k t 0 " O g x e w v " u c { , u c n o q f g n k p k " k ± g t g p " n k v g t c v Ñ t f g " o g x e w v " q n c p i ¾ u v g t o g m v g f k t 0

Adhikary ve Mutsuyoshi (2006) p k p f v , , " ± c n , o c f c . " ± g n d g v q p " \* U H T E + " m k t k n g t k p " p k j c k " m g u o g " o w m c o q f g n n g t k p k p " i g n k v k t k n o g u k p k " u w p o c m v c f , m w n n c p , n c t c m " k m k " o q f g n " d k w d k w n g n d v n g w x g x g v c t c h , p f c p " ¾ p g t k n g p " h q t o Ñ n n g " m e t , n c v , t , u k p k t " c , " o q f g n k p k p . " m k t k n g t k p " m g u o g " o w n

{ c m , p f c p " v c j o k p " g v , v e k . k " u d k v p n k v p " o c w , v " w o t q 0 f " g C h { n g t  
m g u o g " o w m e x g o g v k p k " { w m e t , f c " d g n k t v k n g p " h  
g f g t 0 " C { t , e c . " v c j o k p " g f k n g p " u q p w ± n c t , p  
c ± , m n , , l f g t k p n k m " q t c p , o ' c f x , g " , m ' k d k n w p f o g w t k v p w t  
r c t c o g v t k m " ± c n , o c n c t . " c " o q f g n k p k p " T E " m l  
k { k " { c m e n c f , , p , " i ¾ u v g t o g m v g f k t 0

D g v q p w p " d c u , f c p ± ' x g ' c { c p , o c , f ' c \* f , g + m o ' g { " c f r c , { u c p m  
v c u c t , o f c " k m k " ¾ p g g o " n k g ' u r w n t g t o k g p v k t " g i f k t t - 0 g ' n g m o v l  
o c n k { g v k " x g " | c o c p " c n , e , " f q c u , " p g f g p k { n g  
d c u k v n g v k t k n o k " c p e c m " f q t w " B h t o o d v e g m k n f g  
f k 0 " q \* k p 2 " 3 7 c + r v , , " k ± d c g n t , " v o c c n f x c k . { " g ± n g k n " k x n g " h v c m x k {  
m u k a v e m e t i n i ( f s p t + " v c j o k p " g v o g m " k ± k p " f q t w u c n " q n o  
{ c r c { " u k p k t " c , " \* [ U C + . " f g u v g m " x g m v ¾ t " o c r  
v g m p k m n g t k p k " u w p o c m v c f , f t g h " h D w " x g n , f k o c g f t d " c i t  
v c t c h , p f c p " i g n k v k t k n g p " o q f g n n g t " f c j k n " q  
m e t , n e v , t o c m " k ± k p " j c v c " ¾ n ± Ñ o n g t k " m w n n c  
c p c n k | k p k p . " { c r c { " u k p k t " c x , g p ' , q f ' g f n g ' u o g m  
c n i q t k v o c n c t , p , p . " ± g n k m " h k d g t " v c m x k { g n k "  
o w m e x g o g v k p k " v c v o k p " g f k e k " d k t " f q t w n w m n c  
C P P . " O 7 2 " o q f g n " c c e , " x g " U X O " i k d k " o c m k p g  
m , { c u n c " f c j c " Ñ u v Ñ p " o q f g n n g t " u c n c o , v , t 0

¥ g n k m " g n { c h " m e v m , n , " d g v q p c t o g " \* U H T E +  
m e v o c p n c t . " v Ñ p g n " m e d w m n c t , . " d g v q p " m e p c n k |  
f ¾ g o g n g t k " i k d k " c n c p n c t f c " l { b e t q n a r m e p ( R C ) o , v ,  
± g t ± g x g n g t g " u c j k r " d k p c n c t , p " { Ñ m " v c , { c p "  
m e r c u k v g u k p g " j g o " f g " d g v q p " f c { c p , o , p c " q n  
r q r Ñ n g t n k m " . m p e c p ö α m v o f k k p o r " v \* , 4 2 , 2 " ; ± c n Ñ ± ' b c f c "  
U H T E " m k t k k p k p " f g p g { u g n " x g " u q p n w " g n g o c  
4 7 2 z 5 7 2 z 4 2 2 2 " o o " d q { w v n c t , p f c " Ñ ± " c f g v " U H T  
d g v q p " u , p , h , " x g " m g u o g " g v t k { g n k " U 6 4 2 " ± g n  
m k t k n g t d q { 4 w : p " e i " Ñ p p " g o n k " m Ñ t n g p f k m v g p " u q p t  
± g t ± g x g u k p f g " f ¾ t v " p q m v c f c p " { Ñ m n g o g " f Ñ | g p



{ Ñ m n g t k p " m q p v t q n Ñ " k n g " { c r , n , t 0 " M k t k n g t  
± w d w m n c t " k m k " r c { t Ñ m n { g c o " g d n 3/4 g n t Ñ " p f f w Ñ f Ñ p t f w g n " w t 0 " W { i  
d 3/4 n Ñ o " u c r o c n c t , . " d c n c p i , ± v c p " p k j c k " m , t , n  
m c { f g f k n k t 0 " F g p g { u g n " ± c n , o c f c p " g n f g " g f k  
m w n n c p , n c t c m " o q f g n p n " g φ k g t p k ' . U " H C T E U [ m k " t k c t n c g h , k p p f f  
± c v n c m n c t , p c " m e f c t " c p c n k | " g f k n o k v k t 0 " D g v  
g n g o c p n c t " m w n n c p , n , t 0 " ± " f q p c v , . " 5 " d q { w v n  
O q f g n n g o g " u Ñ t g e k p k g f k m m c m g t k n k p , f 0 4 t U q g n d k  
c p c n k | n g t f g p " g n f g " g f k n g p " u q p w ± n c t " d k t d k t  
f c x t c p , , p , p " f g p g { u g n " m , t , n o c " f c x t c p , ,  
i 3/4 t Ñ n o g m v g f k t 0

¥ g n k m " g n { c h " k v n c g m x k k o { k g " n k k ± k d p g " v q p x " e d w v " v c u c t  
q n c t c m " d g v q p " d k n g g p n g t " c t c u , p f c m k " g v m k n  
f q t w n w w f p x w q " t c m k c p n " v x , g 0 f k k p f 0 v , \* 4 2 3 ± 3 c m , o c f c . " m  
f c { c n , " q r v k o c n g " n ± k g " n d g m v " q n p k " h d k k n " g k p k e o g k " p v k c p p " v c u c  
k n i k n k f k t 0 " D w " v Ñ t " d g v q p . " k p e g " e k f c t n , " j c  
c t c v , t o c . " c - p k ö h p m q 3/4 q n g p k p " ñ k k w " k ± g t k k . " l  
m c t , , o " u g t c w n , k p ± k " . x " g d " g g v k p n w p g " " d f c { c p , o , " Ñ | g t k  
¥ c n , o c " c { t , e c " u q o w v " 3/4 | g n n k m n g t k p " m c t , n ,  
o Ñ o m Ñ p " m , n o , v , t 0 " O q f g n n g t g " f c { c n , " q n c t c m  
i g n k v k t k w p d ' k p q " o x q g ' t w φ ñ c t " j c | , t n c p o , v , t 0 " .  
i g t g m n k " g k n o g " o w m c x g o g v k . " m w o " k p e g n k k "  
c n , p c t c m " q r v k o c n " ± g n k m " n k h n k " k p e g " v c p g n k "

© p c n " x g " ö p k y a 0 v , \* 4 2 2 9 ± e n , o c f c . " d w n c p , m "  
m w n n c p , n c t c m " d c u , p ± " c n v , p f c m k " ± g g k m k h " n k h  
f g k v k t o g " g t k u k p k " v c j o k p " g v o g m " k ± k p " {  
m e r u c o , p f c " 3/4 p e g n k m n g " v f , g t p 0 g " { Ö u 3 g 7 n 2 " 1 ± 5 c 2 n 2 , o o o " c g n d c c t v  
n k h n k " x g " v g n u k | " u k n k p f k t k m " p w o w p g n g t " j c |  
q t c p n c t , p f c " k m k " h c t m n , " ± g n k m " n k h " v k r k " \* j  
p w o w p g n g t k p " 4 : " g c n k k " w k e t k o p g " " i g g t t k m m g g t k " v c p ,  
q n c t c m . " U H T E " g k m k k p " f i g g k k n k o o g " g t k n g t k . "

mwnncp, nctcm" oqfgnngpok " xg" fgpg { ngtfgp "  
mct , nc v, t, no, v, t 0 " Uqppw'±d" kqtn" ckt nckm " njkg" ti" ¾ktm

Vngocv."(2006) p k p " { cr o, " qnf w w" ±cn, ocfc "  
igt k" mc | cp, ncp " ±gnkm" nkhnngtng " i Ñ±ngpfktk "  
ignk vktknogukpg " knk mkp " mc m u c f n t 0 " d D w " ±k "  
i Ñ±ngpfktknok " ±gpvkmnk " dgvpq p " rtk | ocnc t .  
uwpwnow vwt 0 " Mct , nc v, t oc " coce, { nc . " g "  
i Ñ±ngpfktknok " rtk | ocnc t " fc " f k-gemimv g " cn,  
bloknc t, p, " v Ñtgvogm" k±kp " ogxewv " dkt " TKN G  
ikt k kokpfg " dwnwpwnfw. " cpecm" ±gt ±gxgp k "  
dgnktnngpok vkt 0 " ¥cvncm" { c {, n, o, p, p " xg" p "  
igtknoguk" fc , np o g h Ñp g k k p k g t k C g o m k u k h'k d k "  
TKNGO" vctch, pfc p " ¾p-g g k k g p f g g h " g h u g g ñ b ù if g t "  
mercukvgukpk " qnf w wpfc p " hc | nc " vcjokp " gv "  
mwnncp, nctcm" fg k pvc k' txkcnt o, gnuok, " ivg tt g 0 mv k k " uq p

Uqp " { , nnctfc " rtghcdtkmcu { qp " gpf Ñuvtku k "  
fcjc " hc | nc " knik " ©p ¾kuxvggtuokgvngvukf" k\*t WOO'+O kxpgj" qk mk "  
mqpuqtuk { wofc " mgpfknk k p f g p " { gtng gp " ±g "  
ignk vktknoguk " k±kp " { Ñt Ñv Ñngp " ct c v, t oc . "  
(2004) p k p " { cr v, , " d vg " x ±ncgnt, k " ocwpp, npc " tcfp, ct "<i" ¾tc u { qp "  
{ ¾pvgok " vcuctncocm = " gp " w { iwp " ocn | gog " ¾ | g "  
fcxtcp, nct, p, " fg g t n g p f k t o g m " xg " uc { , uc n "  
rtqlgukpfg " dgpkougp i g ¾p " v g t o g f k' c o c u n t o v g n l k "  
HTE" cnep, pfc " Rqtvgmk | ) fg " gp " cmvkh " qncp " W "  
ogvqfq nqlkpkp " vkrkm" dkt " ¾t pg k f k t 0 " " Dw " ± "  
UEUHE" rcp g n n g t k " vcuctnc o k c m". { Ñt Ñw Ñngmp " xfgg' "  
uc { , uc n " ct c v, t ocnc t nc " kniknk f k t 0 "

Dkuej qh 4" 2x2g5" f.k" UHE " gngocpnct, " xg" uvcv "  
Ñ | gt k p f g " { cr, ncp " ct c v, t oc . " g fg gt " okm "  
dgvpqpc tog " f ¾ g o g r n g g t t h g q' t m o, c f p u " n u c' gn cf { gc dgk n' g e g n

### 1.3.2 UHT E ø p k p " R c v n c o c " x g " F c t d g l é' Gvinkknukk'p g ¥ c n , o c n c t

Vandenberghve ve Zwevegem (1990) ø k { p " r o , " q n f w w " ± c n , o c f  
c u m g t k " u , , p c m n c t f c " x g " ¾ p g n o c n p k , " o i , ¾ t x ã g n t g k p n " o f  
¥ c n , o c f c . " F t c o k z " \ E " 8 2 1 : 2 " ± g n k m " n k h " v k r  
q t c p n c t , " x g t k n g t g m . " D g n ± k m c " v g n g m q o ã p k m c  
m w n n c p , o , " c ± , m n c p o , v , t 0 " ¥ c n , o c ñ i k u q p w e w  
¾ | g n k m n g t k p g " u c n c f , , " q n w o n w " g v m k n g t k p  
c ± , m n c p o , v , t 0

Corley (2002) ñ i n ± c n , o c u , p f c . " 3 ; ; 7 " { , n , p f c " Q r  
r c v n c o c u , " k n g " j c u c t " i ¾ t g p " O w t t c j " h g f g t c n  
u q p w e w p f c = " u v t c v g l k m " ¾ p g o g " u c j k r " { c r , n c t  
q n c t c m " j g u c r n c t f j c d' u f c k t m m c c t v , g p " c c n | , c p n c c e u c , " , k " n x g g " "  
t c r q t " q n c t c m " u w p w n o w v w t 0

C d q n j c u u c p " ø g k p r k o , 0 " " \* q 1 n 2 f 2 v 5 + w " ± c n , o c f c .  
o g { f c p c " i g n g p " r c v n c o c n c t , p " { c r , { c " x g t f k  
u q p w e w p f c . " r c p ñ c d { c , u e , , p " ± k' n f g g " g n w g t k p g " m c t ,  
r g t f g p k p " ã u v ã p n ã m n g t k " x g t k n k t m g p . " d g v q p " r  
q n w o n w " f c x t c p , n c t , " i g n k v k t k n g p " r c m g v " r t

N k " x g " f k 2 2 2 r ø p k p " q n , f w c w " c ± ð u g t v " d k t " o g  
j g f g h n g t " ã | g t k p f g m k " { g t g n " f c t d g " g v m k n g t k  
h q t o ã n n g t f g p . " c p c n k v k m " { ¾ p v g o n g t f g p " x g " u  
± c n , o c n c t , " k p e g n g o g p k p ð { ø p t ð a n t c f ð ð g k g p  
f c j k n " g f k n o k v k t 0 " J g o " K o r g t k c n " j g o " f g "  
r g t h q t c u { q p " x g " u ã t v ã p o g " n k o k v n g t k " x g " w { i  
x g t k n o k v k t 0 " U q p " | c o c p n c t f c . v D k b a g r k ñ f M e  
d k t " r c t ± c u , " q n c t c m " q n w v w t w n c p " d g v q p " { c r  
u q p w ± n c t , " d w t c f c " k n m " m g | " t c r q t " g f k n o k v k  
j g f g h n g t k " k ± k p " u c { , u c n " u k o ã ã c n u g ñ p ð w p q " t i n g p  
q t c p n c t , " c n v , p f c m k " m w t w e w " f g p m n g o n g t k " x  
D g v q p w p " v c p , o n c p o c o , " v g m " g m u g p n k " d c u , p ±

f k p c o k m " v g u v " { ¾ p v g o n g t k . " d g v q p w p " fir k p c o k m  
x g " m t k v k m " q n c t c m " f g g t n g p f k t k n o k " x g " v c t  
f k p c o k m " d c u , p ± " f c { c p , o , p , p " d g n k t n g p o g u k p  
t q n Ñ p Ñ " c p n c o c m " k ± k p " i g t g m n k " q n c p " d c m c " c t

Vossoughi x g " f k ∅ p { \* 4 r 2 o 2 , 9 + " q n f w w " ± c n , o c f c . " v  
x g " \ { n q p " m w o c " v c t c h , p f c p " m q t w p c p " d g v q p "  
D g v q p " r c p g n n g t " h c t m n , " m c n , p n , m v c " f ¾ m Ñ n o Ñ  
d , t c m , n o c t w , , m ' 0 j " , | n m c ' x g f g p g { u g n " q n c t c m " ¾ n ± Ñ  
d g v q p " r c p g n n g t " v c t c h , p f c p " c d u q t d g " g f k n g p  
g o k n g p " g p g t l k " k ± k p " Ñ u v " x g " c n v " u , p , t n c t "  
c o r k t k m " n g ð t m c Ñ n n , g n t c v , t , n o , v , t 0 " O g x e w v " r g  
v c t c h , p f c p " m q t w p c p " d g v q p " k ± k p " f c t d g " r c t c  
i ¾ u v g t k n o k v k t 0 " ¥ c n , o c " u q p w p f c " d g v q p " r c  
Ñ | g t k p f g " ¾ p q g n o f n w k " w d " k v t g " u g r v k m v k " u g k f " k n o k v k t 0

U q p " { , n n c t f c " i g n k v k t k n g p " d k t " m q o r q | k  
\* { c m n c , m " 4 2 2 " O R c + " f c j c " { Ñ m u g m " d k t " d c u , p  
d k t " m c t , , o f , t 0 " D k t m c ± " ± g n k m " t n d k g h " " f g c m { n c g p , g m  
x g " v q m n w m " i k d k " o g m c p k m " ¾ | g n n k m n g t k p k " d g r  
p Ñ m n g g t " u c p v t c n n g t k p " o w j c h c | c " { c r , n c t , p f c  
k ± k p " q n f w m ± c T a i ( 2 0 0 9 ) ∅ k p g t { k c l o f k t " Q i " n f c w " w Ñ m u g m " c  
f c { c p , o n , " d g v q p " j g f g h n g t k p " f k t g p e k " { Ñ  
f g g t n g p f k t k n o g m v g f k t 0 " V g u v " f g k m g p n g t k  
k ± g t k t 0 " F g p g { u g n " u q p w ± n c t . " T R E " r n c m c n c t ,  
normal bev q p " \* P E + " r n c m c n c t f c p " f c j c " m , t , n i c p " q  
d k t n k m v g . " c | " o k m v c t f c " ± g n k m " g n { c h " g m n g p o  
¾ n ± Ñ f g " i g n k v k t o k v k t 0 " C { t , e c . - D Y N A ' y a t w u c n "  
f c { c p c p " u k ∅ Ñ n c n { d p t i g t ± g m n g v k t k n o k " x g " v  
x g t k n g t n g " k { k " d k t " w { w o " k ± k p f g " q n f w w " i ¾ t

M t k v k m " c n v { c r , n c t , p " d q o d c " u e n f , t , n c t ,  
i g t g m v k t k { q t 0 " D w " g v m k { k " c | c n v o m a l z e h e k ± k p " g  
m e r n c o c u , { n W u v a S h e i k h ( 2 0 1 3 ) v ± c t n 0 , " o c n c t , p f c . " m t k v  
r n c m c n c t , " r e v n c o c " { Ñ m n g t k p g " m c t , " m q t w { c

r c v n c o c " g p g t l k u k p k " g o g d k n g p " o g v c n k . m " m <sup>3</sup>/<sub>4</sub> r Ñ  
F g p g { u g n " u q p w ± n c t " k n g " p Ñ o g t k m " u q p w ± n c t " d

N k p " x g " f o k k p " { \* 4 r 2 3 , 6 + " q n f w w " ± c n , - o c f c . "   
F [ P C " m w n n c p , n c t c m " r c v n c o c " { Ñ m Ñ p g " { c r , u c n  
g n g o c p n c t " o q f g E l e m e n t a r i n i b g y u t u k u n v e t o n u k d i n a k i k m a k z e m e  
o q f g n k " Ñ | g t k p f g m k " g v m k u k " c t c v , t , n o , " x  
f g h q t o c u { q p " j , | , " c { t , " c { t , " o q f g n f g " j g u c r  
o g u c h g u k . " r c p g n " m c n , p n , a n e l l e r i x p a t l a n f a q i l e n c i v e , " q t c p  
g v m k u k p k " c t c v , t o c m " k ± k p " r c t c o g v t k m " d k t  
u q p w e w p f c . " r c v n c { , e , " { Ñ m " m Ñ v n g u k p k p " x g " g  
v g r m k u k " Ñ | g t k p f g " d Ñ { Ñ m " g v m k { g " i m u n c j e r k r " q n f  
f g k v k t o g p k p " r c v n c { , e , " { Ñ m " m Ñ v n g u k " x g " g  
g v m k n g p f k k " x g " d g v q p c t o g " r c p g n k p " g k n o g u k  
f c " f Ñ Ñ t Ñ n g d k n g e g k " i <sup>3</sup>/<sub>4</sub> u v g t k n o k v k t 0

U g t v " d k t " o g t o k p k p p f " g d n g k v " q g p v " m k k u t k " . j " g h f c g t h m ' n Ñ | " g f t  
h k | k m u g n " q n c { n c t , p " g v m k n g t k p k " f k m m c v g " c n c  
d k t " q n c { f , t 0 " D w " f g k m g p n g t " c t c u , p f c " d g v  
Abdel-Kader ve Fouda (2014) ø p { p r o " , q n f w w " ± c n , o c f c . " 7 2  
g d c v v c " 4 8 " d g v q p " <sup>3</sup>/<sub>4</sub> t p g k p k p . " 4 5 " o o . " 2 . 3 9 7  
f g p g { u g n " q n c t c m " k p e g n g p o k v k t 0 " V g u v n g t . " d  
f q p c v , " q t c p , " x g " v k r k p k p " g n c p n k p k p " v i , <sup>3</sup>/<sub>4</sub> | O n " g  
f g k m g p n g t . " f q p c v , " c , " x g " ± g n k m " n g x j c " c u  
k f k 0 " C p c " d w n i w n c t . " f q p c v , " c , p , p " m q p w o w p  
i <sup>3</sup>/<sub>4</sub> u v g t o g m v g f k t 0 " C { t , e c " d g a p l a m k , w e l m e p i r e n s i g " c t m c  
Ñ | g t k p f g " q n w o n w " g v m k { g " u c j k r " q n f w w " u q p w e

O q " x g (2014) ø p k p r o , " q n f w f Ñ | " ± x g " , n l o k f v c m x k {  
kabuklu (oil palm shell-Q R U + " d g v q p " r c p g n n g t f g " \* H T Q R U E + "  
{ c r , n c p " d t g p g { v g m v k p k p " u q p w ± n c t , " u w p w n o c  
g | k n o g o k " x g " g | k n o k " r c n o k { g " m c d w m n w " h c t  
r q n k r t q r k n g p " n k h " k ± g t k m n g t k f k t " \* ' 2 . 3 . " ' 2  
Q R U ) n k " <sup>3</sup>/<sub>4</sub> t p g m n { g Ñ m g " { d c u m c " p f i c j ± c " x g " p k j c k " f c  
' 2 0 ; " ± g n k m " - " ' 2 0 3 " H r T q Q n R k U r E t " q k r ± k g n t g g p p " " \* <sup>3</sup>/<sub>4</sub> R t R p + g " m j . k " d f t Ñ

mc v " f c j c " { Ã mu g m " q n c p " { c m n c , m " 3 9 " mL ) n k m  
OPSC'ye hibrit liflerin eklenmesi, OPSC) p k p " j g o " f c t d g " j g o " f g "  
f k t g p e k p k " c t v , t c d k n k t . " NYE " x g " j k d t k v " n k h  
¾ n ± Ã f g " c | c n v c d k n k t 0 " Dwp wp n c " d k t n k m v g . " g p  
mq o d k p c u { q p w p w p " p g " ¾ n g ± n Ã k f t g u ' k n j w n k n c k p " , x n c c t d f k , n t g 0 e '  
± c n , o c p , p " q f c m " p q m ± p e hibrit liflerinin FRÖPSC'ni t d a r b e n c t f c r  
f c x t c p , , p c " g v m k n g t k p k " c t c v , t o c m v , t 0

R c p v g n k f g u " ø p g k ' p f r k o , 0 " " \* q 4 n 2 f 3 w 6 + w " ± c n , o c f c .  
betonarme panellerin dep g { u g n " u q p w ± n c t , " u w p w n o w v w t 0 " V  
{ Ã m n g t k " k ± k p " u k o Ã n c u { q p " { ¾ p v g o n g t k p k " f q  
\* T E + " r c p g n n g t = " g m " f q p c v , " q n o c f c p " n k h " v c m  
i Ã ± n g p f k t k n o k x g " HeTcEo " r g c m p { g c n l n " g v e ð h x k { g n k " r q n k  
i Ã ± n g p f k t k n o k " T E " r c p g n n g t " q n o c m " Ã | g t g " 6 "  
3 0 4 " o " m e t g " r c p g n n g t " r c v n c o c " g v m k u k p g " o c t  
m q t w o c . " ± q m " f Ã - t e Ã m t k n j b w a ø ç p g ç t p n k t , p , p " c n  
m c v g i q t k { g " c { t , n o , v , t 0 " F g p g { f g " ± g n k m " ± w  
r g t h q t o c p u c " u c j k r " q n f w w " u q p w e w p c " x c t , n o ,

C q w f g " . (2015) d k k p r o , " q n f w w n w " t ± c c " n { , Ã n o u c r f , n e " r g t l  
n k h " v c m x k { g n k " d g v q p " \* W J R H T E + " m q n q p n c t , p "  
± c n , o c p , p " u q p w ± n c t , " u w p w n o c m v c f , t 0 " F g p g  
v c m x k { g n k " m q o r q | k v " \* E T E + . " ¾ | g n " d k t " W J R H T E  
u k ø Ã n g f k n o k " r c v n c o c " { Ã m Ã " c n v , p f c " v g u v " g f  
r c v n c o c " d c u , p e , " k o r w n u " m q o d k p c u { q p n c t , p c  
c n , p c p " r c t c o g v t g n g t " c t c u , p f c " d g v q p " v k r k .  
ve boyw p c " f q p c v , " q t c p , " d w n w p o c m v c f , t 0 " U q p w ± n  
x g " c t v , m " { g t " f g k v k t o g n g t k " c | c n v c t c m . " j  
r c t ± c n c t , p , " q t v c f c p " m e n f , t c t c m " d g v q p c t o g  
¾ n ± Ã f g " i k g p n k k " i v ¾ k u t v f g k t o g m v g f k t 0 " U q p w ± n c t " c { t ,  
f g v c { n c p f , t o c " x g " d q { w p c " f q p c v , " q t c p , p , p  
f c x t c p , , p , " x g " c t , | c " o q f w p w " g v m k n g { g d  
i ¾ u v g t o g m v g f k t 0

¥ g n k m " n k h p n g k m " u d g g n v " q q n " c i t g c n m g " i Ñ ± n g p f k t k n o k  
u Ñ p g m n k g " u c j k r " q n f w w " k ± k p " r c v n c o c " x g "  
i ¾ u v g t o g m v g f k t 0 " [ c { i , p " c o c ± n , " Ñ t g v k n o k "  
r c v n c o c " x g " f c t d g " { Ñ m Ñ p g f " c ð c t " w w { " i w p ñ c o p c " n k d  
o c n | g o g n g t k p " m w n n c p , o , p , p H " q c i t n c c t v " , x t g o i m f d k c u 0 , " \* h  
{ c r o , " q n f w w " ± c n , o c f c . " f Ñ Ñ m " u Ñ p g m n k m "  
d w p n c t , p " r q n k r t q r k n g p " g n { c h n c t n c " m q o d k p c  
g v m k u k " Ñ | g t k p g " q f c m n c p c p " u c j c " f g p g { n g t k p  
¾ n ± g r h r k l " t r k t m g ' r c p g n n g t " x g " r c p g n n g t f g p " d g n n k  
{ Ñ m n g t k " m w n n c p , n c t c m " { c r , n o , v , t 0 " D g v q p "  
d g v q p w p " r c v n c o c " r g t h q t o c p u , " Ñ | g t k p f g " o k  
x c t , n o , v , t 0

Yoo ve dk 0 " ð 4 2 3 ' 7 { e r o , " q n f w v w " v k m n " x g ð f f c t . d " g  
c n v , p f c " ± g n k m " n k h n k " d g v q p " m k t k n g t k p " g  
D w p w p " k ± k p " 5 " h c t m n , " d c u , p ± " f c { c p , o , " x g " c  
\* U H T E + t ' m k o k n h g f k n k r " v g u v " g f k n o k v k t 0 " [ c t  
k ± g t k k " x g " f c { c p , o , " c t v v , t , n c t c m " g k n o g  
k { k n g o g n g t " q n o w " x g " n k h " k ± g t k k p f g m k " c t  
{ Ñ m Ñ " f w t w o w p n f " c g ' p r g q t v l c k p " u x g " f c { c p , o " c t v , t , n c  
c t v , " i ¾ t Ñ n o Ñ v Ñ t 0 " N k h " k ± g t k k " x g " f c { c p , o  
g k n o g " r g t h q t o c p u , p f c " k { k n g o g n g t g " p g f g p "

¥ g n k m " n k h " v c m x k { g n k " d g v g n p k w p " n \* k U H " T j E c + e " k ¾ d " g  
g m n k . " d g v q p " ± c t r o c " x g " { Ñ m u g m " j , | n , " { Ñ m n g  
U q w h g k c p k (2016) o g p " k f c r v , , " ± c n , o c f c . " f Ñ o g " c  
J q r m k p u q p " d c u , p ± " ± w d w w " v g u t e k i y l e x l e e d i l e n n n c p c p  
o c f f k " v g r m k n g t " u , p , h n c p f , t , n o , " x g " m , u c e  
v Ñ t n g t k p k p " ± g n k m " n k h n g t n g " { c r , u c n " v g r m k n  
¾ p g o k " i ¾ | " ¾ p Ñ p g " c n , p f , , p q p n c ' U H T E g ' p k p t ' m g ,  
j , | n c t , " c n v , p f c m k " ± g n k m " n k h n g t k p " g m k n n g  
i g n k v k t o g m " k ± k p " o g x e w v " n k v g t c v Ñ t Ñ p " i Ñ p e g

H g p i " x (2016) p k p " { c r o , " q n f w w " ± c n , o c f c .  
r g t h q t o c p u n , " n k h " v c m x k { g n k " d g v q p " \* W J R H T E -

± g n k m " | , t j , p " f k p c o k m " v g r m k u k p k " k p e g n g o g  
{ c r , n o , v , t 0 " n m " q n c t c m . " Ñ ± " | , t j " ± g n k  
m q p h k i Ñ t ç ú { m q p p v k p n f " c d ' w t w p " o g t o k u k " c v o c " v g u v  
j g f g h k p f g m k " ¾ n ± Ñ n g p " r g p g v t c u { q p " f g t k p n k  
x g t k o k . " F k h g t c p u k { g n " X g t k o n k n k m " H c m v ¾ t Ñ " l

C D F ø f g " 3 3 " G { n Ñ p n c " " 4 i 2 g 2 n 3 g o p f " g v " g o t g ¾ t f " c g { n g o k p f g  
u c p v t c n n g t k p " d Ñ { Ñ m " v k e c t k " w ± c m " m c | c n c t , p  
m q p w f w t 0 " P Ñ m n g g t " u c p v t c n n g t k p " k n g v o g f  
f q t w n c p o c u , p , p " { c p , " u , t c v , " t d w " { ç ç r { , ¾ p c g t n , k p m  
{ ¾ p v g o n g t " c t c v , t , n o , v , t 0 " N k h " v c m x k { g n k  
o c n | g o g " q n c t c m " m e d w n " g f k n o k v k t 0 " " | g n n k r  
v q m n w m " i k d k " d g v q p w p " i g t k n o g ö f c x k t c ø ; H T F ) þ  
w { i w n c o c " c n c p n e t , p f c p " d k t k " r c v n c o c { c " m e t  
{ c r , n e t f , t 0 " H T E " w { i w n c o c u , p , p " { c r , u c n " f c  
f q t w n c o c m " k ± k p . " H T E ) p k p " ¾ | g n " i d c c m | , g p a , g p " ¾  
malzeme modellemesine dahil edilmelidir. Jeon ve Jin (2016) ø k p " { c r o , " q n f  
± c n , o c f c . " o c n | g o g " f c x t c p , , p , p " ± g k v n k " "  
o q f g n n g o g u k p k " k p e g n g p o k v k t 0 " P q t o c n " d g v q p  
p Ñ m n g g t " d k t " o w j c h c | c " d k p c u , p , p " f c t d g { g " m  
c f , p c " k m k " u c { , u c n " ¾ t p g m " x g t k n o k - 67 k t 0 " C p  
q t c p , p f c " c | c n f , , . " f c t d g " f k t g m d k p k p " f n k h t  
i ¾ u v g v k n ø k

M, { , n o , " d c | c n v " g n { c h . " ± g x t g " f q u v w " Ñ  
¾ | g n n k m n g t k " p g f g p k { n g " u q p " | c o c p n e t f c " d g v  
m c | c p o , v , t 0 . (2016) ø p k u p r q o p , " x " g q " n f f k w w " ± c n , o c f c .  
f c x t c p , o ç f p ç , " k m k v v Ñ t " d c | c n v " - b u k l e k l i p p e s i j o n " \* ö f g o  
h k d t g u ö " x g " ö k Ñ k Ñ m t ± w d w m c t , n " { c t c t , p , " f g  
D g v q p " p w o w p g n g t k . " j g t " n k h v g p " Ñ ± " h e t m n , " c  
f Ñ o g " c , g m v k p g ' f i c ¾ t d g " f v g g t n g p f k t k n o k v k t  
c t c " { Ñ | g { " ¾ | g n n k m n g t k " f g " k p e g n g p o k v k t 0 "  
o w m c x g o g v k p k " c t v v , t f , , p , . " c p e c m " { c n p , | e c  
± c v n c o c " u q p t , ç u t v f ç x f ç p , p , " i ¾ u v g t o k v k t 0



[ c q " x g " f k p " 4 2 3 9 + , " ± c n , o c f c . " f g p g { u  
k ± " r c v n c o c " { Ñ m Ñ p g " o e t w | " m e n c p " ± g n k m " m w v w  
u q t w p w " j g f g h n g p o g m v g f k t 0 " I g ÷ ÷ g v i t 3 4 t n g " " d j g g p t | " g  
J q r m k p u q p ) w p " ¾ n ± g m n g p f k t o g " { c u c u , p c " f c { c  
± g n k m " h c m v ¾ t Ñ " ¾ n ± g m n g o g " u g v k " v c u c t n c p f , C  
i ¾ u v g t k t " x g " u q p w ± n c t . " f , " { Ñ | k g " { c f n g c m p k , " p f k c " m  
j g t " k m k " w ± v c " d w t m w n o c " k ± k p f g " Ñ t g v k n f k k p  
i ¾ u v g t u g " f g " n g x j c " o g t m g | k p f g m k " u c r o c n c t ,  
i ¾ | n g o n g p o k v k t 0 " I ¾ | n g o n g p g p " ¾ n { ± Ñ m v " Ñ t g " x g g t " n  
h c t m . " i g q o g v t k " ¾ n ± g k p k p " c t v o c u , { n c " c t v c  
u c r o c u , p , p " p g f g p n g t k " v c t v , , n o , v , t 0 " F c j  
c c , " ¾ n ± g m n g o g " h c m v ¾ t Ñ " \* d q { w v " g k i s i ) k u k + " j  
q n c t c m " f g g t n g p f k t k n g p " ± g n k m " m w v w " { c r , u ,  
{ c r , n f , 0

R c v n c o c " { Ñ m n Ñ " d k t " { c r , " c p c n k | " g f k n f k  
| q t n w m n c " m e t , n e , n o c m v c f , t 0 " n n i n ' a m i k q t w p . "  
{ Ñ m Ñ p " i k t f k n d g e t u k , p p k ± p " f \* c | n c i o c c u p , + " c p c n k | k p f g p  
m e { p c m n c p , t m g p . " k m k p e k " u q t w p " g v m k " c n v , p f  
i l e i l g i l i d i r . H k i w n k " x g , " r f c k v n 0 " o ĉ 4 2 3 Ñ m n Ñ " k m k " h c t m n , "  
k i t k n g t f g p " \* J G D 3 2 2 " x g " K R G 3 4 2 + " q n w c p " { c  
i ¾ | n g o n g t k . " C D C S W U ÷ v g " i g t ± g m n g v k t k n g p " v  
o q f g n n g t k p f g p " g n f g " g f k n g p " u q p w ± n c t " k n g " m

Yoo ve Banthia (2017) ÷ p , p " { c r w " , ± c " n q , n f o w e f c . " ± g k v n k  
i ¾ | " ¾ p Ñ p f g " d w n w p f w t c t c m " w n v t c " { Ñ m u g m " r g t  
f c t d g " x g " r c v n c o c " f k t g p ± n g t k " m e r u c o n , " d k t  
j , | c " d c n , " n k h " ± g m o g f f ÷ k t p p , , " x g f k p t d g m ± g  
f c x t c p , n e t , " f g v c { n , " q n c t c m " k p e g n g p o k " x g  
W J R H T E " m w n n c p o c p , p " { c t c t n c t , " v c t v , , n o ,  
u , t c f c p " d g v q p f c p " ± q m " i f f c k c " { i Ñ 3 4 t u Ñ m o Ñ p w Ñ t l k " {  
± g n k m " n k h " m w n n c p , o , . " W J R H T E ) p k p " { Ñ m u g m " j c  
n k h n g t g " m , { c u n c " f c t d g " f k t g p e k p k " c t v v , t o c  
{ ¾ p g n k o k . " W J R H T E ) p k p " f c t d g < f k t g p e k p k " h ¾ p g

{ ÃmÃ" { ¾p Ãp f g " j k | c n c p f , , p f c . " f c j c " k { k " f c  
k n k m k u k p g " i ¾t g " f k p c o k m" c t v , " h c m v ¾t Ã" Ã|  
m k t k n g t . " n g x j c n c t . " m q n q p n o c c t " " f x k g t " g n p q ± o n r g q t | k k " v f "  
f Ã | g { f g " k p e g n g p o k " x g " ± g k v n k " h c { f c n , " u q p

I g p g n n k m n g " f Ã o g " c , t n , , " v g u v k . " n k h  
f g g t n g p f k t o g m" k ± k p " m w n n c p , n , t 0 " D w p w p n c "  
c , t n f Ã , ð g x " g { Ã m u g m n k k " j c m m , p f c " v g m" v k r "  
\* 4 2 3 9 { + ø r p d k , p " " q n f w w " ± c n , o c f c . " m , t , e , p , p "  
± g n k m" n k h " x g " r q n k r t q r k n g p " n k h " v c m x k { g n k "  
k p e g n g p o k j v g k α " 0 r " q U n k p r w t ± q n r c k t n g p " n k h " j g o " f g " ± g n  
f c t d g " f c { c p , o , p , p " \* U k + " x g " u q p " f c t d g " f c { c p  
Ã u u g n " q n c t c m" c | c n f , , p , " i ¾ u v g t o g m v g f k t 0 "

[ Ã m u g m" o w m c x g o g v n k " n k h n k " d g v q n d a w p " \* J U E  
x w t i w n c p c p " u v c v k m" f c x t c p , v c m k " c x c p v c l n c t  
o c n | g o g " q n f w w p w " i ¾ u v g t o g m v g f k t 0 " D w p w p n c  
r c v n c o c " r g t h q t o c p u , " k n g " k n i k n k " f g p g { u g n  
(203 9 + ø p g " ± c n , o c f c . " w | w p " c u o c n , " ± f a z l a k m" n k h  
d c u , p ± " f c { c p , o n , . " { Ã m u g m" o w m c x g o g v n k " d g v  
u w p w n o c m v c f , t 0 " H c t m n , " n k h " k ± g t k m n g t k " k n g  
r c v n c o c " { Ã m n g t k " c n v , p f c " d w n w p c p n c t n c " m c t

W n v t c " { Ã m u g m k h r g k h d g o q p ù ñ W J R H T E + . " f c t d  
f c { c p c e c m" Ã o k v " x g t k e k " d k t " o c n | g o g " q n c t c m"  
W J R H T E " Ã { g n g t k " k ± k p " d k t ± q m" h k | k m u g n " f g p  
g n g o c p n c t " \* H G + " u k o ) Ã m k c p u " { m v p t n w e t w " p o f q c f " g W J R H T E " t  
c | " ¾ p g o " x g t k n 0 R \* 4 2 3 9 { + ø r p d k , p " " q n f w w " ± c n , o c f c . " w | w p " c u o c n , " ± f a z l a k m" n k h  
f c t d g " u k o Ã n c u { q p n c t , " k ± k p " { g v g t n k " d k t "  
c o c ± n c p o , v , t 0 " R c v n c o c " c p c n k e | b e t o ñ ( K E C ) p " m w n  
o q f g n k p k p . " f c t d g p k p " p g f g p " q n f w w " v g r m k n g  
m c p , v n c p o , v , t 0 " D w " p g f g p n g . " d g v q p " o q f g n n  
o q f g n k " \* E U E O + . " o g x e w v " f g p g { u g n " x g t k n g t  
f g k v 0 t W r d k u v k n t " u q p w ± n c t . " ¾ p g t - u k n t g v p n " g o o r g | "  
f c x t c p , , p , " { g v g t k p e g " i ¾ u v g t g d k n f k k p k " x

u , m, v , t o c " m w x x g v n g t k p k "  $\frac{3}{4}$  p e g f g p " d g n k t n g {  
o q f g n " m w n n c p p ' h f c t d g g g f d c g f k h g g r m k n g t k p . "  
w { w o " k  $\pm$  k p f g " q n f w w " i  $\frac{3}{4}$  | n g p o k v k t 0

Yooa ve Banthia (2019)ø p , p " { c r o , " q n f w w "  $\pm$  c n , o c f  
p q t o c n " n k h " v c m x k { g n k " d g v q p n c t , p " \* H T E ) n g t +  
n m c t q c m . " o g x e w v " q n c p "  $\pm$  g k v n k " f c t d g " v g u v k  
u w p w n o w v w t 0 " F c j c " u q p t c . " g n { c h " v A t A p f g p  
H T E ) n g t k p " q t v c m "  $\frac{3}{4}$  | g n n k m n g t k . "  $\frac{3}{4}$  t p g k p " f c t d  
darbe dirg p e k " A | g t k p f g m k " g v m k u k " x g " i g t k n o g " j ,  
\* { c p k " o c v t k u " i A e A . " { A m n g o g " m q w n n c t , " x g "  
g n { c h n c t n c " \* { c p k "  $\pm$  g n k m . " r q n k o g t k m . " m c t d q  
kar u c o n , " f c t d g " f k t g p  $\pm$  n g t k " h c t m n , " { A m n g o g "  
f c t d g "  $\frac{3}{4}$  | g n n k m n g t k "  $\pm$  g k v n k " n k h n g t n g "  $\frac{3}{4}$  | g v  
m c t , n c v , t o c n , " f c t d g " f k t g p e k . " j c p i k " v k r v  
d g n k t n g o g m " k  $\pm$  k p " f g g t n g p f k t k n o k v k t 0 " U q p  
{ c p k " w  $\pm$  w e w " m A n . " u k n k u " f w o c p , " x g " e A t w h w p w p  
k p e g n g p o k v k t " x g " f c t d g " g v m k u k p k p " c t v o c u ,  
kombinau { q p n c t , "  $\frac{3}{4}$  p g t k n o k v k t 0

¥ g n k m " n k h " v c m x k { g n k " d g v q p w p " \* U H T E + " m c  
o g m c p k m "  $\frac{3}{4}$  | g n n k m n g t k " p g f g p k { n g " f A p { c "  $\pm$  c r  
o c n | g o g " o q f g n n g t k . " f c t d g " x g " r c v n c o c " { A m n g  
u k o A n g " g v o m n m " k m w k n p n " c u p , , m m , , v , t 0 " D w p w p n c " d k  
p q t o c n " d g v q p " k  $\pm$  k p " i g n k v k t k n f k k p f g p . " o q  
x g " m c { o c " i g p k n g o g u k p k p " k j o c n " g f k n o g u k " x g  
i k d k " f k g t " c f { g | u c c x n c " p v v c c j l o n k e p t n , g " t u f g " { a p g , . f k , m n c  
\* 4 2 3 ; { ø p k p " q n f w w "  $\pm$  c n , o c f c . " U H T E " k  $\pm$  k  
i g p k n g o g u k p k p " x g " | q t n c o c " q t c p , p c " d c n , " o  
c n , p f , , " { g p k " d k t i " g m w k t w e k w t " k o n c o n k | g v o k g t " O o " q [ f g g p n k k " " c  
i k t k " r c t c o g v t g n g t k { n g " U H T E ) p k p " o g m c p k m "  
i g t k n o g f g " i g t k n o g " u g t v n g o g u k " x g " { w o w c o c  
d k n g g p n g t k p k p "  $\pm$  g p k f c n k { " c f r A m n g o ' g f " c m q c w n n c t p , ,

LS-F [ P C " u q p n w " g n g o c p " m q f w p c " f c j k n " g f k n o k v  
x g " f q t w n w w " t e r q t " g f k n g p " f g p g { u g n " u q p w ± n

¥ q m " u c { , f c " ± c n , o c . " ± g n n k w m " n n c k p h , " n v o c c m x , k p { , g p  
v c m x k { g n k " r q n k o g t " \* H T R + " m q o r q | k v n g t k p " i Ñ  
f c t d g " x g " r c v n c { , e , " { Ñ m n g t g " m e t , " f c { c p  
i ¾ u v g t o k v k t 0 " H T R " x g " d g v q p " c t c { u c , r p , f n c c m k , " p ð  
f k p c o k m " { Ñ m n g o g { g " o c t w | " m e n c p " g p " | c { , h " n  
H T R " k n g " i Ñ ± n g p f k t k n o k " d g v q p c t o g " \* T E + " { c  
x g " v c u c t n c p o c u , " k ± k p . " H T R " k n g " d g v q p " c t  
c p n o c c u , n " ¾ p g o n k f . k \* t 4 2 ' 3 ; { w o p p k , p g " " d f k f w w " ± c n , o c  
\* D H T R + " v c d c m e n c t , " k n g " U H T E " c t c u , p f c m k " f k p  
d k t " c t c v , t o c " { c r , n o , v , t 0 " D g v q p " r t k | o c n  
h c t m m , ñ k k ñ k c e o k " \* ' 2 0 7 . " ' 3 0 2 " x g " ' 3 0 7 + " m w n  
g v o g m " k ± k p . " : " o " 1 " u ) { g " m e f c t " ± g k v n k " { Ñ m n  
D w " ± c n , o c f c . " i g t k n o g " - k a y m a t e p k i s i g i b i d e h e y d e t " m w x  
u q p w ± n w e n t o " w u w " x g " v c t v , , n o , v , t 0 " H k d g t " j c e o  
f k p c o k m m " { d o c " o q f g n k " ¾ p g t k n o k " x g " f q t w n c p o

V g t ¾ t " u c n f , t , n c t , " i k d k " ¾ | g n " f w t w o n c t f c  
i k d k " f c t d g " { Ñ m n g t k p p " " d i c g t x w | g " m ñ c q m d c w m w c p f f , c t p 0  
c n v , p f c " i g p g n n k m n g " d k t m e ± " r c t ± c { c " c { t , n , t  
betona dahil edilir. L c o p c o " x g " p f k p " 0 { " c \* r 4 o 2 , 4 2 " + q n f w w " ± c n , o  
i g q o g v t k n g t g " u c j k n o " c o g v t | ö k m " c f n c t p d g " g ñ Ñ m n " g n t k k p g k  
k p e g n g p o k v k t 0 " O g t o k " g m n k p f g m k " ± c t r o c " v  
p c o n w " g p g t l k u k p g " x g " ; . " 3 3 " x g " 9 0 8 4 " o o " q n o c  
M c p e c n , " w ± " v k - 5 k ñ Ñ m k h o k " h d j t a c k p h , n p g f t c . " " m w 3 n n c p , n o ,  
6 2 2 z 6 2 2 " o o " d q { w v n c t , p f c " x g " 3 2 " k n c " 3 2 2 " o  
r c p g n n g t g " f ¾ m Ñ n o Ñ v Ñ t 0 " J g t " r c p g n " o g t m g | f  
\* f c t d g " q n c { , " ¾ p e g u k " x g " u q p r n u t , " d k ± k b k p 6 g  
v q r n c p o , v , t 0 " U q p w ± n c t . " r c p g n n g t f g " { c { i  
d w n w p f w w p w " i ¾ u v g t f k < " r g t h q t c u { q p . " m e d w m  
o g t o k n g t " k ± k p " m e n , p n , m . " r c p g n n g q { k p p c ' f f , c 0 t " d g  
D w p w p n c " d k t n k m v g . " d Ñ { Ñ m " x g " m ¾ t " w ± n w " o g t o

k ± k p " j g o " m e n , p n , m " j g o " f g " n k h " j c e k o " q t c p , " q n c t c m " r c p g n " m e n , p n , , p c " x g " n k t h o " k k " ± c g n t v k , p k f p c q c t , | c " o q f n c t , p , p " r g t h q t c u { q p f c p " m e d w m n c p m e { o c u , . " c t v c p " r c p g n " m e n , p n , , p , p " x g " h k d g

[ w u q h " x g " o f k k p " 0 { " c \* r 4 o 2 , 3 2 " + q n f w w " ± c n , o c f c . " m e n c p " f ã | " p g v q p a t ' d g " { x p , o n , " ± g n k m " n k h n k " c f c x t c p , , " ã | g t k p g " f g p g { u g n " d k t " c t c v , t R g t v c j c p c p " P e u k q p e n " O c n g | { c " © p k x g t u k v g u k . D k t k o k " v c t c h , p f 8 p 2 i o g t ' z g 8 2 g o v k z k 8 2 R o v k d 0 { v : " c f g v " d g v q p c t o g " r c p g n " v g u v " g f k n o k v k t 0 " j c e k o " q t c p , p f c " \* ' 2 0 7 . " ' 3 0 2 " x g " ' 3 0 7 + " m e p e o ) n k m " d k t " o g u c h g { g ' c ' y g t f g e y k t { ã m ã p " r 3 v m e 0 c r c v n c { , e , " { ã m n g o g { g " o c t w | " d , t c m , n o , v , t 0 " n k h n k " d g v q p c t o g " r c p g n k p " r c v n c { , e , " { ã m n g i ¾ u v g t o g m v g f k t 0

V g p i " x ( 2 0 0 8 ) f { k c r v , c f " c ± . c " n f , c t o d g " { ã m n g o g u k p g " h k d g t " v c m x k { g n k " d g v q p w p " \* U H T E + " f k p c o k m " v e l e m a n k o d u L S - F [ P C ) { , " m w n n c - p l a s t i k h i d r o d i n a m i k G a l z e m e v k m o q f g n k . " U H T E ) p k p " f q t w u c n " q q ' 0 j c n p p g ' w 0 g v k g e r i l m e - g m k n " f g k v k t o g " g t k u k " k n g " o q f g n n g o ¾ | g n n k m n g t k p k " x g " f q t w u c n " q n o c { c p " i g t k n o g u , m , v , t o c " v g u v k " x g " { c t o c " v g p a r a m e t r e l e f i n e r , n f , C d g n k t n g o g p k p " d c u k v " d k t " { q n w " ¾ p g t k n o k v k t j g f g h k p k p " c t m e " { ã | g { k p f g m k " o g t o k p k p " c t v , u q p w ± n c t n c " k { k " d k t " w { w o " i ¾ u v g t o g m l e g f k t 0 " u c p v t c n n g t k p " x g " f k g t " v g u k u n g t k p " { ã m u g m " k ± k p " m w n n c p , n , " x g " x g t k o n k f k t 0

[ g " x g " f k p k 0 " " \* { 4 c 2 3 v : , + , " ± c n , o c f c . " f k p c o k m k ± k p " ± g n k m " h k d g t " v c m x k { i n d e l i k a m i k d a r b e c e s t l e r i m U H T E + " f g p g { n g t k p k " u w p o c m v c f , t 0 " ' 2 . " ' 2 0 9 7 " x g " ' 3 f k p c o k m " u , m , v , t o c " f g p g { k . " W 9 7 " o o " ± c r n , " u k u v g o k " m w n n c p , n c t c m " i g t ± g n e n p g n c v t k , t " k e n n o v k , p v f k c

± g n k m " n k h " k ± g t k m " n k h n g t k p " d g v q p " o c n | g o g " f k p c o k m " { c r , " o q f g n k . " f q t e m e l l g t k " i g t k p k o " f g g t k " x g " v g r g " i g t k n k o k p k p . " g n { c l i ¾ u v g t f k 0 J ö h n s o q - h q q w k u r , u c n " u i k g p t k k p p " k v c ' p j , , o | , , " " x g g i g t k p k o " q t c p i n g c t t k , p p k , o p " " g i g t t k k m g k t o k " v g o g n k p f g . " m q o r q | k v k p k p " f k p c o k m " d k t " j c u c t " q n w v w t w o c n | g o g " f k p c o k m " { c r , " o q f g n k . " f q t e m e l l g t k " i g t h c m v ¾ t Ñ " x g " ± g n k m " n k h " k ± g t k m " h c m v ¾ t Ñ p g " d c m e t , n , m " i g n g p " o c n | g o g " r c t c o g v t g n g t k " g n f g w { f w t o c " u q p w ± n c t , p , p " f g p g { u g n " x g t f k k n g k t p n k g " i ¾ u v g t k t 0

Nataraja x g " f 4 2 0 7 + . " ± g n k m " n k h n g t k p " d g v q p " o c n | g o g " f k p c o k m " { c r , " o q f g n k . " f q t e m e l l g t k " i g t h c m v ¾ t Ñ " x g " ± g n k m " n k h " k ± g t k m " h c m v ¾ t Ñ p g " d c m e t , n , m " i g n g p " o c n | g o g " r c t c o g v t g n g t k " g n f g w { f w t o c " u q p w ± n c t , p , p " f g p g { u g n " x g t f k k n g k t p n k g " i ¾ u v g t k t 0

### 1.3.3 Plak Elemanlar ile n i k n k " [ c r , n e p " Y c n , o c n e t

U k n k p f k t k m " m e d w m n c t , p " k m k " h c t m n , " o q f g n k f k { c h t c o n c t " m w n n e p , n e t c m " u e r o c n e t , p " ' : 2 " x 7 2 + " g p " c | c " k p f k t k n f c k t c k " v i , ¾ u o v e g n t c k t n f o c k p " v x k g " 0 g " n f u q p w ± n c t f c p . " u k n k p f k t k m " m e d w m n c t " k ± k p " ¾ f q t w n e p o , v , t . " d w " f c " g m q p q o k m " h c { f c n e t " u

Yaghoobi ve Torabi (2013) { c r v , m n e t , " ± c n , o c f c . " k m k t e m e l l g t k " Ñ | g t k p g " q v w t c p " h q p m u k { q p g n " f g t g e g

{ c r , n c p " r n c m c n c t , p " v g t o c n " { Ã m n g t " c n v , p f c  
d q { w p e c " v g m " v k r " u , e c m n , m " c t v , , " \* W V T + . "  
f c , n , o n c P t V , F ' + \* " N q V n F c " t x c g m " Ã ± " h c t m n , " v g t e c n " { Ã r  
d q { " q t c p n c n " ; p m g p m t q t c p , . " i t c f { c p " k p f g m u k "  
r c t c o g v t g n g t k p " m t k v k m " d w t m w n o c " u , e c m n , m  
c ± , m n c p o , v p t , 0 " G n q v , w h w p t h m c j k r " h q p m u k { q p g  
f k m f ¾ t v i g p " r n c m c n c t , p " m t k v k m " d w t m w n o c " u  
c t c v , t o c e , n c t , p " i g n g e g m v g " u c { , u c n " x g " c  
m , { c u n c o c " u q p w ± n c t , " q n c t c m " j k | o g v " g f g d k n l

R g t x g | " x g , u f l p , 0 " m 4 2 3 w h n c t , p , p " v k e c t k " m q  
i g t k n o g " f g g t n g t k " Ã | g t k p f g m k " g v m k u k p k " u v  
± ¾ | Ã o Ã " x g " { Ã m u g m " o g t v g d g f g p " m c { o c " f g h q t c  
O g x e w y h m c v , t o c n , " ± c n , o c " k ± k p " { c { i , p " q n c  
{ c | , n , o , . " { c p k " N W U C U . " C P U [ U " x g " C N I Q T " u g  
f k m m c v g " c n , p o , v , t = " U U U U . " E E E E . " E U U U . " E H  
d w t c f c " E . " U " x g g p H o k u , t c a n d m e g f m g p g d c u k v " o g u  
x g " u g t d g u v " \* h t g g + " m g p c t n c t , " k h c f g " g f g t 0 "  
u , p , t " m q w n n c t , " k ± k p " k { k " u q p w ± n c t " x g t k t m g  
J U F V " u q p w ± n c t , m p c g " m g , p { k c p u g n " c m ' g ¾ | o g g n " n i k g t k n o g n g t k  
f g g t n g t k p k p " f q t w n w w " m g p c t " m q w n n c t , p c  
f k g t k p g " Ã u v Ã p n Ã Ã p Ã " k f f k c " g v o g m " | q t f w t 0 "  
m q w n n c t , p c " q n f w m ± c " d c n , f , t 0

Ustc " x g " f k v 0 c " t c 4 2 p 8 e p " { c r , n c p " ± c n , o c  
h c t m n , n c o c u , " f w t w o w p f c . " r c p g n n g t k p " c d u  
t g c m u k { q p " m w x x g v n g t k . " c t m c " { Ã | g { " { g t " f g  
k p e g n g p o k v k t 0

Tan ve Paramasivam (1994). " ± g n k m " n k h n k " d g v q p c t o g " f ¾  
f c x t c p , , " k p e g n g p o k v k t 0 " 3 6 " m c t g " n g x j c p ,  
f g u v g m n g p o k " x g " o g t m g | f g m k " m c t g " d k t " c n c p  
m c f c t " { Ã m n g p o k o g k u t G h V g k v " g v m k p t c p , m n ; m g f  
n k h n g t k p " f j " c e ¾ o g g h , c b m o n m u k p a m e t i f c , x " g " v c , { , e , " r n  
boyutu r k f k 0 " V g u v " u q p w ± n c t , . " n k h n g t k p " j c e k o " h

f g g t n g t k p k , c t v n c m " m e n , p n , , p , p " c t v o c u , p ,  
{ ã m ã p g " x g " p k j c k " { ã m g " { q n " c ± v , , " x g " c { t , e c  
c t v o c u , { n c " d k t n k m v g " c | c n u c " d k n g " u ã p g m n k  
c t v , t c t c { m ã m ã p v ã p c . o " c c m o c " { ã m ã p ã p . " p k j c k " { ã  
i ¾ u v g t o g m v g f k t 0 " R c p g n " m e n , p n , , p , p " c t v o  
¾ p g o n k f k t 0 " F ¾ g o g " m e n , p n , , p , p " c t v v , t , n o  
k ± k p " i g p g n n k m f n g g " k w n { f i k w t p 0 " d k t " u g ± k o

Tan and Venkateshwaran (2019). " i g n g p g m u g n " f q p c v , " q n o c  
f g n o g " m e r c u k v g u k p k " c t c v , t o c m " k ± k p " f g p g {  
o o ) n k m " q p " k m k " m e t g " n g x j c " v g u v " g f k n o n k v k t 0  
d c u , p ± " f c { c p , o , . " f ¾ g o g " V a L e / D e ) ; b u n a d a V e h a c i n x g " h k d g  
q t c p L e f u z u n l u k t u r v e D e ± g n k m " n k h n g t k p " ± c r , f , t 0 " ¥ c r  
m e r c u k v g u k " ã | g t k p f g " g p " { ã m u g m " g v m k { g " n g x  
t e m x k { g " k p f g m u k " x g " d g v q p w p " d c u , p ± " f c { c p ,  
i g q o g v t k u k p k p " g v m k u k . " p k j c k " { ã m " ã | g t k p f g "

P i w { g p . \* x 4 g 2 " 3 f 5 k + . " w n v t c " { ã m u g m " r g t h q t o c p u  
\* W J R R J H T E + " g k n o g " f c g v m p u k , c t ã ç g v k p ó g m k , t d  
p w o w p g . " f ¾ t v " p q m v c n , " d ã m ã n o g " m w n n c p , n c t c  
3 2 2 z 3 2 2 z 5 2 2 " o o 5 " \* q t v c + " x g " 3 7 2 z 3 7 2 z 6 7 2 " o o  
u ã p g m n k k p k p J H g T E k ) n p o k p f " g d " q W J w R v v g n k m k u p k " ã | t g t k p f  
h c t m n , " n k h " k ± g t J H T E g ' t v l g p g " g d H J R C 1 h a d i m e k % 1 , W J " R V J R  
d ã m ã n ã " ± g n k m " o c m t q " g n { c h " x g " ' 2 0 - H F R 6 2 u c . " f  
' 3 . 2 " d ã m ã n ã " ± g n k m " o c m t q " g n { m c h t " , x g , " ó , 3 " . k 2 ± g n t , k u  
Her iki UHP-J H T E . " g k n o g " o w m c x g o g v k . " p q t o c r  
p q t o c n n g v k t k n o k " g p g t l k " g o o g " m e r c u k v g u k  
C { t , e c . " f c j c " f ã ã m " J H g T E 3 g " k u p ã p g g n k m k o g k " f k c n x g " c W J  
boyutuna d e j c " f w { c t n , { f , 0 " P w o w p g J p H T E ) d p k { p w v g w " k e n |  
o w m c x g o g v k . " p q t o c n k | g " g f k n o k " u g j k o " x g " p  
¾ p g o n k " ¾ n ± ã f g " c t v c t m g p " p w o w p g p k p " c n v " { ã |  
g m k n f g " c | c n o m , " ± v g , m t o g " " F m c j r c c " u { k ã H F R 6 2 g n u m g n e n i n c j k r " V  
d q { w v w " c t v v , m ± c " g k n o g " o w m c x g o g v k p f g .  
p q t o c n n g v k t k n o k " v q m n w m v c " f c j c " m ã ± ã m " c |



gerinin kapasitesine sahip UHP-HFRC, numunenin boyutuna daha az hassasiyet  
i ¾u v g t o k v k t 0

O k e j g n u " x g o p k f p k " 0 c r \* o 4,2 3 " 5 q n f w w " ± c n , o c f c  
d g v q p w p " \* U H T E + " ± c v n c o c " u q p t c u , " o w m c x g o g v  
Ã | g t k p g " f g p g { u g n " x g " u c { , u c n " d k t b c p t p " v o t e  
h k d g t " v k r k . " h k d g t " f q | c l , " x g " p w o w p g " d q { w v v  
f c x t c p , , " Ã | g t k p f g m k " g v m k u k " Ã | g t k p g " d k t " .  
v g u v " k ± k p " ± - g m m g f i g " f i g g k k n k g o d k ' n k g n p k " u n d f i g u d k p  
r t q u g f Ã t Ã p Ã p " i g n k v k t k n o g u k f k t 0 " D w " c o c ± n  
f c { c n , " d k t " m , t , n o c " o q f g n k " f Ã u g Ã j p k Ã o ' b Ã t k r g g  
u c { , u c n " d k t " q r v k o k | c u { q p " r t q u g f Ã t c Ã c k n g " w  
¾ p g t k u k p k p " { c p , " u , t c " d Ã { Ã m " ¾ n ± g m n k " r n c n  
p w o w p g n g t k " Ã | g t k p f g " f g p g { u g n " c t c v , t o c " {  
i g q o g v t k " m q w n n c t , " c n v , p f c " v c , o c " m w x x g v  
j c m m , p f c " k n m " k | n g p k o n g t k " x g t o g m v g f k t 0 " H k  
j g o " f g " v q r n c o " g p g t l k " c d u q t r u k { q p w p w p " c t v  
elyafen-d q { " q t c p , . " d c j u g f k n g p " ¾ | g n n k m n g t " Ã | g t  
d k t " c f , o f c . " c t v c p " ± g m o g " i g t k n k o k " k n g " c |  
j k r g t d q n k m " x c t u c { , n c t c m . " i g t k n k o f g m k " k m  
u k o Ã n c u { q p " m q f w { n c " d k t " r c t c o g v t k m " q r v k o k |  
{ c u c p ± , Ã p m " m u Ã c r o c " u g x k { g n g t k p f g " f c j c " { Ã m u g r  
j k r g t d q n k m " d k t " k n k m k p k p " f g p g { u g n " g t k n g  
i ¾ u v g t k n o k v k t 0 " J g t " k m k u k " k ± k p " f g " m , t , n o  
x g " g k n c k { o c n " g ± t , k n " c q t t , v t " x g " h c t m n , " p w o w p g " d q { w v  
¾ n ± g m n k " p w o w p g n g t n g " w t c , t m g p " f c j c " f Ã Ã  
f g g t n g t k " k n g " u q p w ± n c p c p " d k t " d q { w v " g v m k u l

I c p g u c p " x g " " f k k m k 0 " " { \* ¾ 4 p 2 n 3 Ã : " + f Ã | n g o " k ± k " g { n g o  
f w x c t " r c p g n n g t k p k p " r g t h q t o c p u , " Ã | g t k p f g m  
d c o d w " v c m x k { g n k " d g v q p " f w x c t " r c p g n k " p w o w p  
kadar bir eksantriklikte uygulanan f Ã | i Ã p " { c { , n , " { Ã m " c n v , p f c " c  
D w " ± c n , o c f c " g n g " c n , p c p " c n v , " p w o w p g f g p " Ã  
o g t m g | k p f g " c ± , m n , c " u c j k r " r c p g n n g t f k 0 " p

q t c p , p c " x g " 3 0 8 9 g . p " 3 g 0 p : " 4 d ' q x { g " " q 4 t ) c n p k n m c " t f , g p c k " x g " 3  
k p e g n k m " q t c p n c t , p c " u c j k r v k 0 " U c n c p c p " c ± ,  
' 4 7 ) k { f k 0 " ¥ c n , o c . " c ± , m n , - d q p " q t c p , p f p m k p  
f w x c t " r c p g n n g t k p k p , " . p " k k j p c e k g " n { k ã m ã ã p t ã c p p " , c p | f c c m f k , " c  
{ ã m ã p ã p " f g " c t v v , , p , " i ¾ u v g t o g m v g f k t 0

O q j c k u g . p \* 4 2 3 ' 9 f k " - d q { ' k q t g q ( H / L ) g v p b e t o n T i p l ( b e t o n  
f c { c p , o n , " d g v q p " x g " 5 " { ã m u g m " f c { c p , o n , " d g v  
duvar paneller k p k p " { c r , u c n " f c x t c p , , p c " k n k m k p "  
U q p w ± n c t . " C T " f g g t k p k p " 3 . 4 7 ) v g p " 4 . 2 2 ) { g "  
f w x c t " r c p g n n g t k p k p " { ã m " v c , o c " m e r c u k v g u k p  
p k j c k " { ã m ã p ' 6 ' . 3 9 . { 7 ) " v g ã p ' v ã ã p ã " i ¾ u v g t o g m v g f  
k ± k p . " C T " 4 . 2 2 ) f g p " 3 . 4 7 ) g " f ã v ã ã p f g " p k j c  
O R c ) f c p " 3 4 2 . 6 " O R c ) { c " f ã m k g g g p g q p ã p ã w o w m c p  
artmakta, H / L u , t c u , { n 4 0 3 2 4 q n c p " : 7 2 p g n n g t " k ± k p " c t v  
4 2 8 0 8 9 " q n o c m v c f , t 0 " D g v q p " f w x c t " q r t ( H / L ) g p n g ' t \* k  
d c n , f , t . " d w t c f - d q ' { P " U c E t " c r p c , p p g , n p n " g 3 . k 4 7 ' ) g v p g p " 4 . 2  
duvar panellerinin yanall sehiminin arto c u , p c " p g f g p " q n w t m g - p . " T R E  
d q { " q t c p , p , p " 3 . 4 7 ) v g p " 4 . 2 2 ) { g " c t v o c u , . "  
c | c n o c { c " p g f g p " q n o w v w t 0 " C { t f , c ) e b e t o n d u v a p c n " u g j  
panelinin mukavemeti 33,5 MPa'dan 120,4 MPa'ya " { ã m u g n f k k p f g . " { c p c

F w x c t n c t " ã | g t k p f g " k m k " { ¾ p n ã " g { n g o " t c r  
{ c r , n o , v , t 0 " U c j g d " x g " F g u c { k " \* 3 ; ; 2 + . " 4 6 "  
m c n , p n , , p , p " c n v , f c " d k t k p g " d g t k m , - l o y n u c p y t k  
q t c p H / p 2 0 p 8 ' 9 \* " k n g " 4 0 2 2 " c t c u , p f c " f g k k { q t + " d  
4 2 " k n c " 4 7 " O R c " c t c u , p f c " f g k k { q t + " " x g " f k  
f c { c p , o , " ã | g t k p f g m k " g v m k u j k p k k " f k p c e - l o y , g o f , k p n g ' t  
q t c p n c t , p f c m k " \* J 1 N + " c t v , n c " c t v v , , " u q p w e

Doh (2002) o w p " { c r ± c , n , o c f c . " c n v , " m e t g " d g v q  
f c { c p , o n , " d g v q p " x g " 5 " { ã m u g m " f c { c p , o n , " d g v  
q t c p , " \* C T p " f x g ' d g , o , p , p " d g v q p " f w x c t " r c p g n n  
g v m k u k " k p e g n g p o k v k t 0 " F q j . " f g p g { u g n " ± c n ,  
r c p g n n g t " k ± k p " g m u g p g n " f c { c p , o " q t c p n c t , p ,

u q p w e w p c " α t ϕ ω n " x g t 0 ã ñ u g m " f c { c p , o n , " d g v q p " q t c p n c t , p f c m k " c | c n o c . " J 1 v ) f g " 5 2 ) f c p " 6 2 ) c ' 4 9 . 3 " q n o w v w t 0

Almeida (2009)ø p , p " { c r v , , " { ã u m c u p g f m x " k n ± k " u r c c p u g " n v n g g | t v c , o c " m α r c c p u g k n v " g l u j k p w k v m c t , p c . " { c r , u c n " i g q o g x w t i w n c p o , v , t 0

J k o c u t g g " x g ð g f v k q p 0 w p \* " 4 e 2 k 3 p 9 u + k " x g " m c n k v g u k . { ã | f g n g t k . " p b / n v k e p - d k t n " q t d h / p + , " i \* k u d t k ? " ± g k v n k " r c e t k i s i n i b e n k t n g o g m " k ± k p " c t c v , t o c e , n e t " v c t c h , p ± c n , o c n c t , p " k p e g n g o g u k p k " u w p o c m v c f , t 0 " ¾ p g t k n g p " f g p m n g o n g t " m w n n c p , n e t c m " j g u c r n c m e t , n c v ± , g t t o o c g u m , v p g , f " k f t c 0 " " k c n , o c " c { t , e c . " f w x i k d k " g p g t l k " { q w p n w w " q n f w m ± c " h c | n c " o c n | u ã t f ã t ã n g d k n k t " d k t " f q c n " o c n | g o g " q n c p " d c c

E j q w f j c t { " x o g n { f c k r o 0 " \* " 4 q 2 n 4 2 w + w " ± c n , o c . " U H v c u c t , o , " x g " i g n g p g m u g n " d g v q p " \* E E + " f w x c t " r c p e n k | k " g v t c h , p f c " f ¾ p o g m v g f k t 0 " U H T E " f w x c j c e o k " q n e t c m " h e t m n 3 , 0 " 9 { 7 ã | x f g g " n ' g 4 t 0 f 7 g + " " \* ± ' g 2 n . k " m " 3 n . k " h D w " ± c n , o c " m e r u c o , p f c . " U H T E " f w x c t " r c p g n n g { ã m n g o g n g t k p g " o c t w | " d , t c m , n o , v , t 0 " C { t , e c ± , u , p f c p " k p e g n g p o k ± v k t c Q ' c P g v q p ' v ã l u g t k k p f n g m n g p o g u k { n g " f c j c " { ã m u g m " f g g t n g t " i ¾ u v g t d ã { ã o g " k n g " ± g n k m " n k h " k n g " { c r , n c p " f w x c t " r c { ã u m c r o c " i t c h k k " ± k t | " k k n ± f g k t k k p k f " g q r " v ' k 3 o 0 w 9 o 7 " " v h g k r d g g " C { t , e c . " f c t d g " v g u v k p f g . " f c j c " { ã m u g m " n k h " h c | n c " d w n w p o w v w t 0

[ w u q h " x g " ø f p k ϕ 0 " ð \* ; 4 2 q 2 n f w w " ± c n , o c f c . " r c v m e n c p " f ã | " d g v q p c t o g " x g " p q t o c n " f c { c p , o n , " f c x t c p , , " ã | g t k p g " f g p g { u g n " d k t " c t c v , t R g t v c j c p c p " P e u k q p c n " O k m g k t n ' c H © m ã x g g u k v B c k r D k t k o k " v c t c h , p f c p " i g t ± g m n g v k t k n o k v k t 0 "

d g v q p c t o g " r c p g n " v g u v " g f k n o k v k t 0 " ¥ g n k m " h  
 q t c p , p f c " \* ' 2 0 7 . " ' 3 0 2 " x r e k t e d i s P a n z e l l e r , 0 1 6 m ' i k e b i c n , " ± g n  
 o g u c h g { g " { g t n g v k t k n o k " 3 " m i ) n , m " r c v n c { ,  
 { Ñ m n g o g { g " o c t w | " d , t c m , n o , v , t 0 " D w " c t c v  
 d g v q p c t o g " r c p g n k p " r c v n c { , e ρ ÷ p { u Ñ n ' n g g g f k c n  
 i ¾ u v g t o g m v g f k t 0

U k p i j c n " x g " f C D C S ' W U 4 2 n 3 w : n n c p , n c t c m " u q p n w  
 o o f g n n g t k p " f q t w n w w p w " i ¾ u v g t o g m " k ± k p " c  
 { Ñ m n g o g u k p g " m c t , " u c { , u c n " u k o Ñ n c u r { z q p " i g t  
 m e n c p " V P V " c , t n , , " x g " u , p , t " m q w n n c t , " i  
 f w t w o n c t = " v Ñ o " m g p c t n c t , " u Ñ t g m n k . " 4 " w | w p "  
 m g p c t " u Ñ t g m u k | . " 4 " m q o w " m g p c t " u Ñ t g m u k | . "  
 m g u p g v " f w t w o n c t , f , t 0 " m k " m , u c " m g p c t " u Ñ t g  
 i g t k n o g p k p " u , t c u , { n c " 5 4 " o o . " 8 0 ; ; " o 1 u "  
 m q p h k i Ñ t c u { q p n c t " c t c u , p f c " g p " k { k " u , p , t " r  
 m g p c t , " u Ñ t g e n i u k " | q " n q w n c p p " " n i g g x j k n o g p k p . " d w " ± c n  
 m q w n n c t c " m , { - 7 c 2 u " n q t " c { p c , m p n f c c " , c n | " c ' n 5 f 2 , , " d w n w p o w  
 m g p c t " u Ñ t g m u k | " q n c p " f ¾ g o g p k p " ¾ p g o n k " {  
 u q p w e w p c " x c t , n o , v , t 0

#### 1.4 V g | k p " F Ñ | g p k

[ c r , n c p " v g | " ± c n n ¾ n Ñ o f g ' p v q m n w c ÷ c m v c f , t 0 '  
 k ± g t k k " c c , f c m k " i k d k " ¾ | g v n g p g d k n k t <

n ¾ n Ñ o f g " { c r , n c p " v g | " ± c n , o c u , " k n g " k n i  
 d k n i k " x g t k n o g m v g f k t 0 " D w " d ¾ n g Ñ o k " " ± k g n g k " n k " n n i k k h n k  
 f g p g { u g n " x g " p Ñ o g t k m " ± c n , o c n c t . " ± g n k m " n k  
 f c { c p , o , p , " g n g " c n c p " ± c n , o c n c t . " ± c n , o c  
 r c t c o g v t g n g t k " f g u v g m n g { g p " ± c n , o c n c t "  
 f g t g g p f k t k n o k v k t 0 "

mkpek "lifli ¼mã, f g ñ k m" nk h g k g 'd g g m p ð b m h ¾ | g n r  
n k h n k " d g v q p n c t n c " k n i k n k " m w n sedilmektadır. p " { ¾ p g v c

©± ã p e ã " d v ¾ g | ã " o f ± g n , o c u , " m c r u c o , p f c " k p e  
teorilerk p f g p " d c j u g f k n o k v k t 0 " C { t , e c " d w t c f c "  
m w n n c p , n c e c m " q n c p " d c u k v " m k t k " { c m n c , o , p  
bahsedilmektedir.

F ¾ t f ã p e ã " ± d ¾ k ã " f n g k " h o m k f " g a k ñ | q g o w g " v w t w n o c u ,  
o q f g n k p " ñ g v g t c a v ã " t " f f g n p c g t { n u c g " n n ' c o t c u n , , n ' c o g v " , u t q , p " q m  
{ c r , n c p " r c t c o g v t k m " ± c n , o c " x g " u q p w ± n c t , " .

D g k p e k " ± d ¾ k ã " f n g k " h n k " d g - v g t p " " f r g p l g n v l g t d p " k  
v c j o k p " g f g e g m " o c v g o c v k m u g ã ð f d g k " t c ' { o t q , f e g n " " ¾ p p g  
o c v g o c v k m u g n " o q f g n " k n g " u q p n w " g n c o c p n c t "  
c n o c m v c f , t 0

C n v , x p g e ' , u " q p " d ¾ n ã o f g " k u g " v g | " ± c n , o c u , "  
k p e g n g p g p " r c t c o g v t g n g t g " i ¾ t g ñ a l q p w k t n @ ' t [ k p ð g  
d ¾ n ã o f g " v g | " ± c n , o c u , " m c r u c o , p f c " i g n g e g r  
¾ p g t k n g t " { g t " c n o c m v c f , t 0

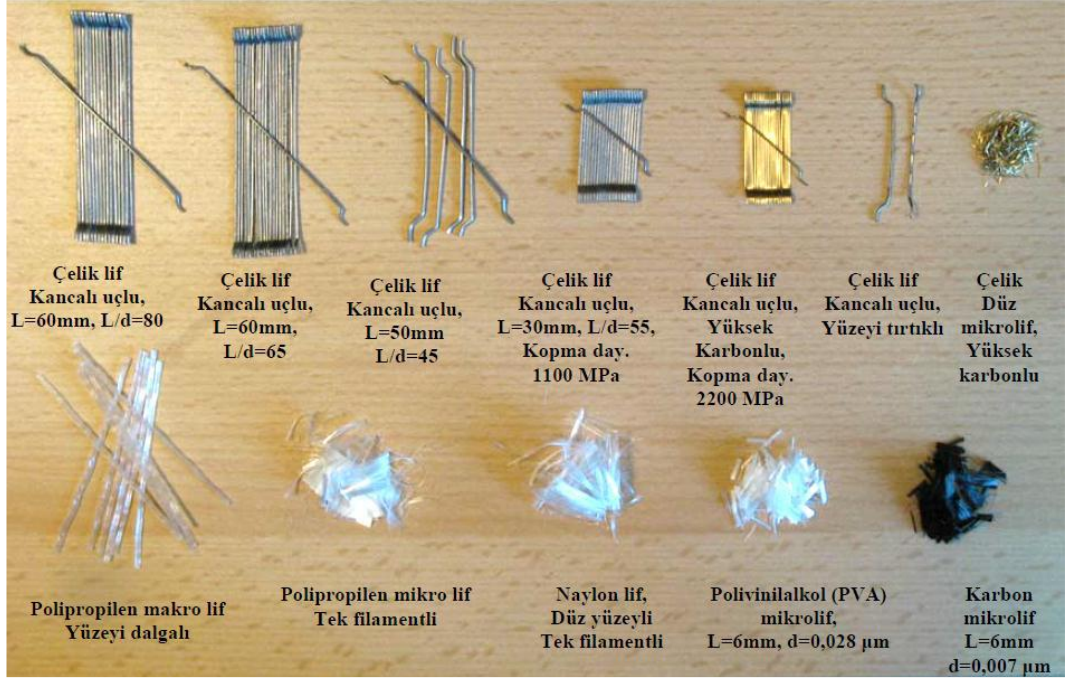
2.N HN " DGVQP " \ GNN MNGT " XG  
 [ " P G V O G N M N G T

J g t " o c n | g o g p k p "  $\frac{3}{4}$  | g n n k m n g t k " d c m c " d k t "  
 i  $\frac{3}{4}$  u v g p k f g p d g w " v Ñ o " { c r , u c n " v e n g r n g t k d d m c t , n  
 o c n | g o g n g t k p " w { i w p "  $\frac{3}{4}$  | g n n k m n g t k p k " m w n n c p  
 $\frac{3}{4}$  | g n n k m n g t k p f g p " v c o " q n c t c m " { c t c t n c p o c m " k =  
 x g " d w p n c t , ñ d k c p k p k p g f g p k f k t 0 "

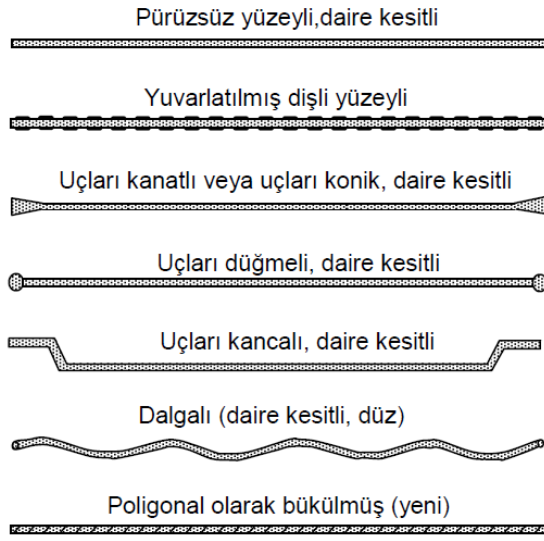
I g x t g m " d k t " o c n | g o g " q n c t c m " d g v q p w p " k u v g  
 f c { c p , o , p , p " \* d c u , p ± "-3f7c) { k c + p " , x o g " p m g u ' o { g c " m f n æ { c , p m  
 f c { c p , o , p , p : 2 ð k n ð f Ñ m Ñ m 5 7 i n o c u , f , t O e l l e r D g v q p "  
 k n g " d w " i g x t g m n k m " r t q d n g o k . " d g v q p c " m c v , n c p

N k h n k " d g v q p = " ± k o g p v q . " c i t g i c " x g " ± q  
 m e t , v , t , n o c u , { n c " o g { f c p c " i g n g p " d g v q p " q n c  
 n k h n g t " m c v m k ñ . o " c d g v q p g w k " d k n g g p n g t k p f g p f k  
 f c { c p , m n , n , m . " u Ñ p g m n k m " x g " ± c v n c m " m q p v t q n

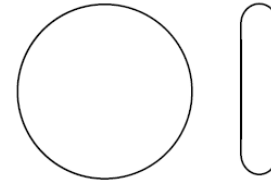
D g v q p " k ± g t k u k p f g " { c { i , p " q n c t c m " m w n n c p  
 ± g n k m . " r q n k r t q r k n g p . " n f c k t t d " 20 3 g x n 0 k " n D ' w p m n a k " k k g  
 g p " ± q m " m w n n c p , n c p " n k h " v k r k " d g v q p c " m c | c p f ,  
 liflerdir. C { t , e c " d w " n k h " v k r n g t k p k . " i g q o g v t k m "  
 o Ñ o m Ñ p f Ñ 2004' ø f g g m k m { i w n c o c " m x g h c p c n e p t a k m a g f  
 x g t k n o k v k t " \* P e c c o c p . " 4 2 2 5 + 0 " D w p c " i  $\frac{3}{4}$  t g " n k l  
 q n c d k n f k k " i k d k . " { Ñ | g { " g m k n n g t k " x g " i g q o  
 tiplerk p g " t c u v n c o c m " 0 Ñ ø f n Ñ m k Ñ i n 0 h o g m k n h 5 , p " { c  
 n k h n g t k p " h c t m n , " d q { " \* N + " x g " ± c r n c t f c " \* f +  
 $\frac{3}{4}$  | g n n k m n g t k " Ñ | g t k p f g " q n f w m ± c " g v m k n k " q n f w  
 f k g t "  $\frac{3}{4}$  p g o n k "  $\frac{3}{4}$  | g n n k m p ð w g " p c t k p a k o t v k p , " \* \* N I f  
 d q { w v u w | " d k t " r c t c o g v t g f k t 0 " ¥ g n k m " n k h n g t "  
 m e t d q p n w + " x g { c " { Ñ m u g m " \* { Ñ m u g m " m e t d q p n w  
 q n c d k n o g m v g f k t n g t 0 " ¥ g n k m " u k p n g n ð p f t t e n , m 6  
 f c " f c x t c p , , " g v m k n g { g p 2 3 } . c t c o g v t g n g t " c t c u ,



g m k : t 4 0 k n f k m n g t k " o d r | t g a g e g ". i " 3 4 t 2 g ' 9 n k h n g t

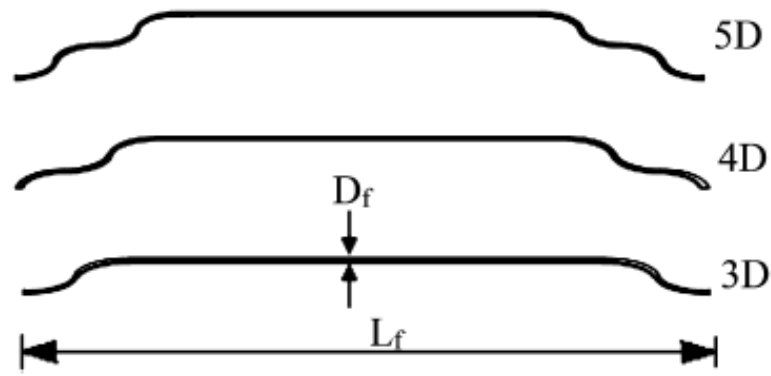


(a)



(b)

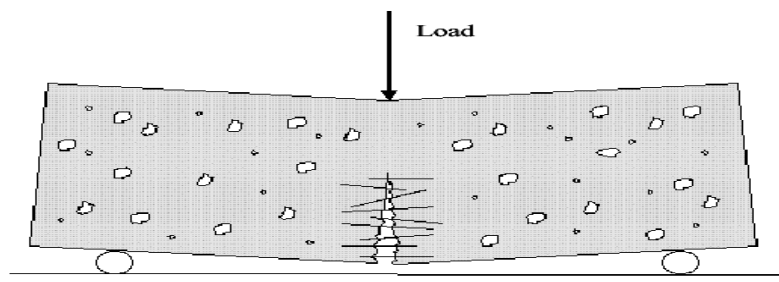
g m k : t 4 0 p f c " m w n k b p g n k p " ± g q b g v t k m " g m k n n g t k < " \* c + " m g u k v " i g q o g v t k n g t k " \* { w x c t n c m " x g " f Æ | + " \* P



g m B: 4 10 m " n k h n g t k p " m 3/4 r t Ñ a n g o g " 3/4 | g n n k k

N k h n k " d g v q p n g t k f v n g' t d k Ñ p v f Ñ g p " u n c k h n " c p o c u , " i g t g m g  
d g v q p " k ± g t k u k p f g " j q o q l g p " q n c t c m " f c , n o c u ,  
f c " d q | w n o c o c u , f , t 0

D g v q p c " ± g n k m " n k h " v c m x k { g u k p f g m k " c u , n "  
d w n w p f w t c p " i g x t g m " d g v q p w p " u Ñ p g m n k k p k " c t  
d g v q p f c " ± c v n c m " q n w w o w p w " i g e k m v k t 2 4 ) t g m " x g  
\* m 3/4 r t Ñ a n g o g " g p k p " u Ñ p g m n k m " x g " ± g m o g " f c { c p ,  
\* O g j v c " x g " O q p v g k t q . " 4 2 2 8 + 0 " D 3/4 { n g e g " ± g m o g  
± g n k m " n k h n k " d g v q p w p " f g h q t o c u { q p " { c r c d k n o  
(Banthia ve Sappakittipakorn, 2007; Gopalaratnam ve Gettu, 1995; Nataraja vd.,  
1999). D w " f w t w o f c . " 3/4 | g n n k m n g " g k n o g p k p " g v m k n l  
f q p e v , n e t , " k n g " m w n n c p , n f , , p f c " { c r , " g n  
d q { w v n c p f , t , n e d k n g e . g g k n k m " u 3/4 h m g o g k m . o' Ñ a n g o g " Ñ p f  
d w n w p o c o c m v e f , t 0 " ¥ c v n c o c { c " m e f e t " i g ± g p "  
± c v n c o c f c p " u q p t c " d g v q p " h c | , " f g x t g f g p " ± , m o



g m B: 4 10 m " n k h n g t k p " m 3/4 r t Ñ a n g o g " 3/4 | g n n k k



## 2.1 $\forall$ g nNknh'n k " D g v q p w p " M w n n c p , o " C n c p n c t ,

Kompozit d k t " o c n | g o g " q n c p " d g v q p " i g p g n " q n c  
f c { c p , o , . "  $\pm$  g m o g " f c { c p , o , . "  $\pm$  c v n c m " q n w v w m  
g o o g " m e r c u k v g u k " c  $\pm$  , u , p f c p " | c { , h "  $\frac{3}{4}$  | g n n k m n  
d w " | c { , h "  $\frac{3}{4}$  | { g m r g k m r g n t g k p' f q g n " w t 0 "  $\forall$  g n k m " n k h n k " d  
u c n c f , m n c t , " d g n k t i k p "  $\tilde{A} u v \tilde{A} p n \tilde{A} m n g t k p f g p$  "  
sahiptirler\* g m k n " " D w 0 " m w n n c p , o " c n c p n c t , " w " g m k n f

É F g r t g o g " f c { c p , m n , U  $\tilde{A}$  p c g m m k c t k , p p " " { k  $\tilde{A}$  m u c g u n  
k u v g p k n g p " d w " v  $\tilde{A}$  t " { c r , n c t f c " m w n n c p , n c d k n k t

É Kolon-m k t k " d k t n g k o " d  $\frac{3}{4}$  n i g u k p f g .

É G p f  $\tilde{A} u v t k$  " { c r , n c t , p f c .

É g x " u v c d k n k | g u k p k p " u c n c p o c u , p f c .

É Beton-d g v q p c t o g " d q t w n c t " x g " c n v { c r , " o c n

É J c x c c n c p , " m e r n c o c n c t , p f c .

É Fabrika depo x g " j c p i c t " f  $\frac{3}{4}$  g o g n g t k p f g 0 " [  $\tilde{A}$  m  
{  $\tilde{A}$  m u g m " q n o c u , . "  $\pm$  c v n c m " m q p v t q n  $\tilde{A}$  " u c n c o c u ,  
f k t g p  $\pm$  " i  $\frac{3}{4}$  u v g t o g u k p f g p " f q n c { , " g p f  $\tilde{A} u v t k$  " { c r

É N k o c p " m e r n c o c n c t , p f c .

É [ q n " m e r p n f c c o 0 c " n l c g p g n n k m n g " { q n " v g o g n n g  
d k v  $\tilde{A}$  o n  $\tilde{A}$  " o c n | g o g " m w n n c p , n , t 0 " D w " v  $\tilde{A}$  t " m e r n c  
d  $\tilde{A}$  {  $\tilde{A}$  m "  $\frac{3}{4}$  n  $\pm$   $\tilde{A}$  f g " {  $\tilde{A}$  | g { " f  $\tilde{A}$  | g p u k | n k k p g " p g f g p "  
 $\pm$  g m o g " i g t k n o g n g t x k g p " k  $\pm$  p c " v d n k c t o " c m { , c u " o m , c p t , u " , v " c m q , { t c t 0  
{ q w p n w w p c " u c j k r " { q n n c t f c " d  $\tilde{A}$  {  $\tilde{A}$  m "  $\frac{3}{4}$  p g o " v c  
{  $\tilde{A}$  m u g m " d g v q p " g n f g " g f k n o g u k p k " u c n c t 0

É R  $\tilde{A}$  u m  $\tilde{A}$  t v o g " d g v q p " w { i w n c o c n c t , p f c . "  
{  $\tilde{A}$  m u g m " f c { d d p e d i l i r . n , " d g v q p " g

É p e g " m c d w m" { c r , n c t f c 0 " M g u k l o v m" p m c n , p  
x g t f k k p f g p " k p e g " m c d w m" { c r , n c t f c . " m w d d g n  
{ c r , " g n g o c p n c t , p f c " m w n n c p , n o c m v c f , t 0 " "

É D Ñ { Ñ m" u , e c m n , m" h c t m n c t , p e " o c t w | " m c r

É H k f t q n k m" { c r , n c t f c 0 " I g n g p g m u g n " d g v  
c , p o c " x g " f c t d g { g " m c t u , " f k t g p e k . " f g p k | " q  
¾ | g n n k m n g t k p f g p " f q n c { , " u w " { c r , n c t , p f c " m w

É ¥ q m" { Ñ m u g m" o w m c x g o g v n k " d g v q p n c t f c .

É Patlamaya k c t , " f c { c p , m n , " { c r , n c t f c " m w n n c

É [ Ñ m u g m" f c { c p , o c . " u Ñ p g m n k g " x g " f c { c  
{ c r , " g n g o c p , p " Ñ t g v (Akbulut, 2006)." m w n n c p , n o c m v c f , t



(a)



(b)



(c)



(d)



(e)



(f)



(g)

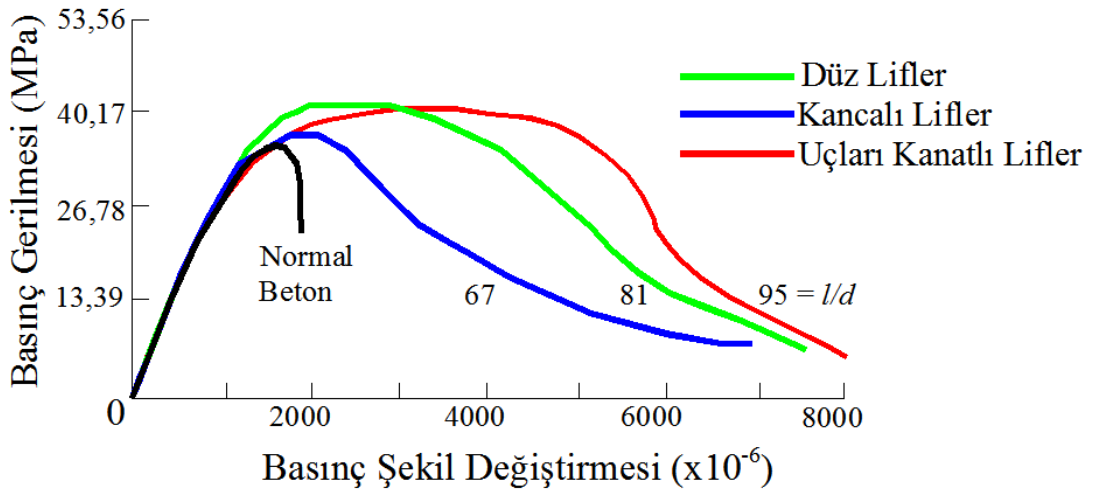
g m E: ñ 'g 4 0 m" n k h n k " d g v q p " w { i w n c o c n e t , < " \* c + " g p f Æ u v  
w { i w n c o c u , . " \* f + " k p - ß g " 4 2 3 5 m ! g R g g h p d e k h \* W T N v k o f g " 5  
m ¾ r t Æ " m k t k k . " \* h + " v Ä p g n " u g i o g p v r g g t " k { Æ \* m i u g " m M d t g k ø ' f 3 5 "  
q n c p " M ¾ r t Æ " \* O g j v , c ' x g , " Ø q p 4 2 k t q . " 4 2 2 8

## 2.2 ¥ g n k m D'g Nvk q p v k p " " O g m e p k m " " | g n n k m n g t k

D g v q p c " ± g n k m " n k h " m e v m , u , p , p " g p g t l k " { w v  
f c { c p , o , . " ± g m o g " x g " g k n o g " o f c c n { c c t p f , c o " , d p g , n " k c t t n v g  
C n v " d e n , m n e t f c " f g v c { n , " d k t " g m k n f g " ± g r  
d c j u g f k n o k v k t 0

## 2.2.1 D c u , p ± " F c { c p , o ,

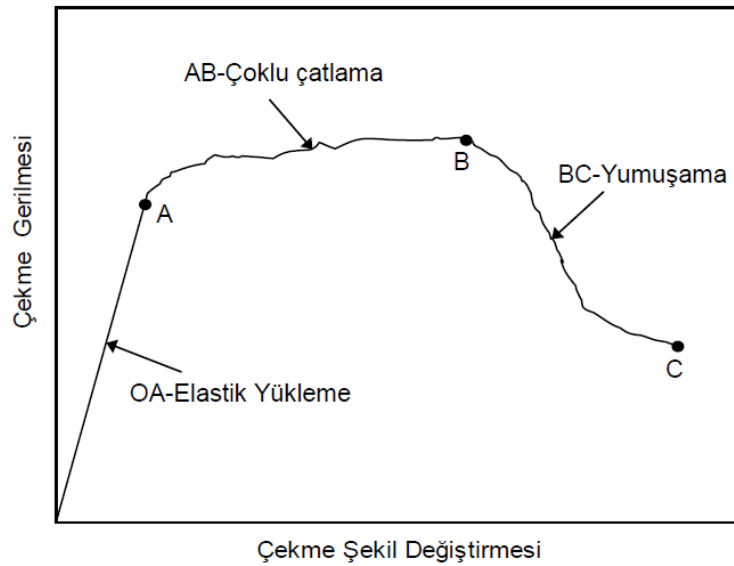
D g v q p c " ± g n k m " n k h " g m n g p f k k p f g . " d g v q p w { c { , n o c u , p , " ¾ p n g f i k { k ü d k n k p e g m n g f i k q d W F w o w " g v m k u k { n g " f g x t g { g " i k t g p " ± g n k m " n k h n g t . " ± g r f c { c p , o , " Ñ | g t k p f g m k " g v m k n g t k " k j o c n " g f k n g v c t c h , p f c p " { c r , n k c " p 3 " 2 ± 2 c " n q , n c o p c . f " c j . c " e p k c o t e k g p " n ' k 4 " q t x g " F o c z ? 3 ; " o o " q n c p " ± g n k m " n k h n k " d g v q p " u k r { c r , n o , " x g " d c u , p ± " f c { c p , o , p , p " g p " h c | n c " x f 0 " \* 3 ; 9 : + " v c t c h , p f c p c f c r k n g p " f l k u g p ± d k g p g f k n o k " v k g r n k k m " i f g g t k k n o v g k t o g " g t k n g t k " g m k n " n k h " k ± g t o g { g p " p q t o c n " d g v q p " k n g " ± g k v n k " v m c t , n c v , t , n i o ¾ t Ñ n f t Ñ " Ñ " g i m k d k " 4 d g r l k m " g n ' k h n g t " o k m v c t f c " g v m k n g o k n g t f k t " x g " ± g n k m " n k h " v k r f Ñ | g { f g f k t 0 " R k m v g p " u q p t c " v c o c o g p " i ¾ ± g p " p d e f o r m a s y o n y a p m a y a d e v a m e v o k n g t f k t 0 " G m u g p g n " d c u , p ± p q t o c n " d g v q p n c " d g p | g t " f c x t c p , " i ¾ u v g t g p g t k k n f k m v g p " u q p t c " p q t o c n " d g v q p c " i ¾ t g " f c q n f w w " i ¾ t Ñ n o Ñ v Ñ t 0



g m k : i ' g 4 e p g m u g n " d g v q p w p - " g m k r N F d o k (S h a h k o p , d 1 9 7 8 ) g k n b g g t k

## 2.2.2 $\forall g m o g " F c \{ c p , o ,$

D g v q p f c "  $\pm g n k m$  " n k h " m w n n c p , o , p , p "  $\frac{3}{4}$  p e  
 i g e k m v k t o g u k " x g { c "  $\pm c v n c m$  " { c { , betonolan p , " g p i  
 u , { t , n o c " f c x t c p , , " p g f g p k {  $\pm g n$  " k q m " w n , k l p n " k d " w  
 aksenel  $\pm g m o g$  " f c { c p , o , p f c " p q t o c n " d g v q p f c p "  $\pm q$   
 x g " o c n | g o g p k p " u  $\tilde{A}$  p g m n k k " f g " d w " f c x t c p , "  $\pm$   
 $\pm g m o g$  " f c { c p , o , p c " w n c v , , p f c " d g v q p w p "  $\pm$   
 f c { c p , o , p c " m c v x m g " u  $\pm$  g " n q k t m " c n f k c h p n " g m t c " n g m v c m k " p n g k t  
 x g { c "  $\pm c v n c m$  " i g p k n k k " n k h " d q { w p w p " { c t , u  
 f g x c o " g v v k k " m c d w n " g f k n k t u g . "  $\forall N F D \emptyset p k p$  "  $\pm$   
 $\pm g m o g$  " v q m n w w " f c " p q m a d e v a h d d e r  $\forall$  q g m k p  $\frac{3}{4}$  t



g m  $\forall$  k 4 g m "  $\pm g m o g$  " f g p g { k p f g g "  $\forall$  k n f " D f o g w p k " v v k k r t k o n g " " i g g t t k k n u o k g " \*  
 1998= " [ c n  $\pm$  , p . " 4 2 2 ; + 0

C { t , e c " d g v q p f c " m w n n c p , n c p "  $\pm g n k m$  " n k h "  
 S j c j " x f 0 " { c r v , , "  $\pm c n$  , o c f c " i  $\frac{3}{4}$  t  $\tilde{A}$  n o  $\tilde{A}$  v  $\tilde{A}$  t 0  
 $\pm g n k m$  " n k h " k  $\pm$  g t g p " d g v q p " p w o w p g n g t k - p k p "  $\pm$  g  
 g m k n " f g k g n k m g  $\frac{3}{4}$  t  $\tilde{A}$  n f g n g v k f k t " \* U j c j " x f 0 . "



g m R:G" 4 0 o g " g v m k u k p f g " m k t k " m g u k v k p f g " q n w c p " i g t k  
d g v q p " k ± k p . " \* d + " ¥ N F D " k ± k p " \* [ c n ± , p . " 4

G k n o g " f c { c p , o , p , p " d w " g m k n f g " c t v o c u ,  
o c v t k u v g " k n m " q ± p t v c n " c m g n q k n r w " n k w l m n v g t p k p u " d g v q p c "  
c t c u , p f c m k " c f g t c p u " d <sup>3</sup>/<sub>4</sub> n i g u k p k p " ± c v n c o c u , p  
v c , o c u , " q n e t e m " c ± , m n e p c d k n k t 0





















































































































































































































































































































































































































































































































































































