?K *!"#-2,("+-!

=K /L4 #+7 !"

;K)$#$(" #+'"+('5-.51$%%5# '4-!' 5"-51$6 5
4# '',#

MK)$#$(" #+'"+('5-.51$%%5# '4-!' 5"-58-")51$6 5
4# '',# 5$!252 8#+'5(-%%+'+-!5

NK H,77$#3

/L4 #+7 !"'5-!51$%%5# '4-!' '5 "-5"',!$7+5+74$("

Experiments on response of wall

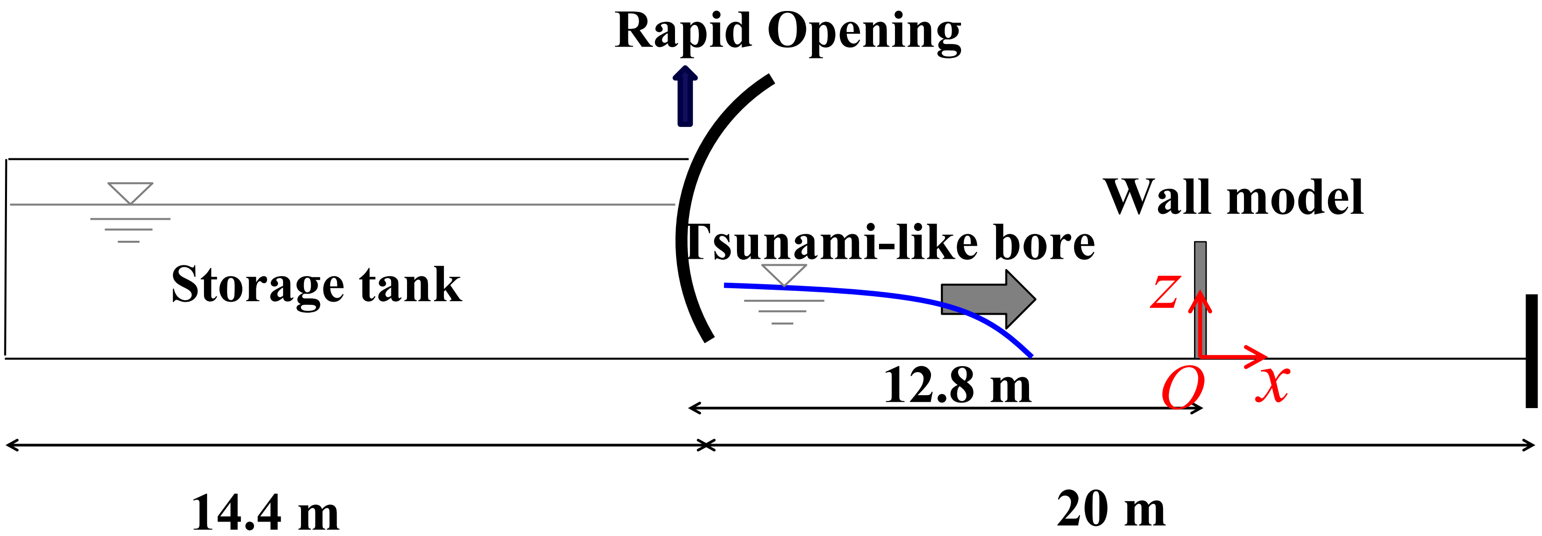
- to tsunami wave pressure
- to both tsunami wave pressure and debris collision

H4 (+.+($"+- !5-.51$%%5 7 -2 %'

- -!(# " 51$%%
  - F +9)"U5?KN5 7
  - V+2")U5?K>5 7
  - J)+(G! ''U
    - 5>K>N5 7 5Q&'(R
    - 5>K?5 7 5Q&)((R
    - 5>K?N5 7 5Q&)'(R5
- & 51$%%5Q!)((R
  - F +9)"U5?KN5 7
  - V+2")U5?K>5 7
  - J)+(G! ''U5>K?>5 7

*+,-./.01/-.+2/3	!.4+5*-,.6.+/0-7/4*
MNKW5 C O$5	>K;N5X

0%- 15J34



89* : 0/ ;<.	"+4/4790 : 7/ . -0 = . </30 4+0 /3 . 0/ . >/0> . , /4*+0? 6 @	"+4/4790 : 7/ . -0 = . </30 4+0 /3 . 0>/*-72 . 0/7+A0? 6 @
B;<.0)	>	?K;
B;<.0C	>	?KW
B;<.0D	>K;	=K>

H4 (+.+($"+- !5-.52 8#+' 7 -2 %

?K H)$4

- ✓ -%, 7 !

=K H+Y

- ✓ Z+$7 " #U5>KN?5 7
- ✓ F +9)"U5>KM5 7

;K C$''

- ✓ M@5G9

MK H,#.$(57$" #+$%5

?K 0-%3 ")3% ! 5.-$7

=K H" %

/L4 #+7 !"5($' '

E 799	89* : 0/ ;<.	F . G-4>
&'(	J34 5?	D- !
	J34 5=	D- !
&)((	J34 5;	D- !
		0-%3 ")3% !
		H" %
&)'(	J34 5;	D- !
		0-%3 ")3% !
		H" %
!)((	J34 5;	D- !
		0-%3 ")3% !
		H" %

/L4 #+7 !"5($' '

E 799	89* : 0/ ; < .	F . G-4>
&' (	J34 5?	D - !
	J34 5=	D - !
&) ((	J34 5 ;	D - !
		0 - %3 ") 3% !
		H" %
&) ' (	J34 5 ;	D - !
		0 - %3 ") 3% !
		H" %
!) ((	J34 5 ;	D - !
		0 - %3 ") 3% !
		H" %

C $' ,# 7 !"5+" 7 '

- **Pressure**
  - Center line of the upstream face of the wall
  - z = 0.01, 0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.49 m
- **Concrete strain**
  - z = 0.039, 0.09, 0.18, 0.27, 0.36, 0.64, 0.92 m
- **Reinforcement strain**
  - z = -0.1, 0, 0.09, 0.18, 0.27, 0.36, 0.64, 0.92, 1.2 m
- **Acceleration of wall**
  - z = 1.5 m
- **Water depth**
  - x = -7.6, -5.4, -2.7 m
- **Velocity (ADV)**
  - x = -5.4 m

?K *!"#-2,("+-!

=K /L4 #+7 !"

;K)$#$(" #+'"+('5-.51$%%5# '4-!' 5"-51$6 5

4# '',#

MK)$#$(" #+'"+('5-.51$%%5# '4-!' 5"-58-")51$6 5

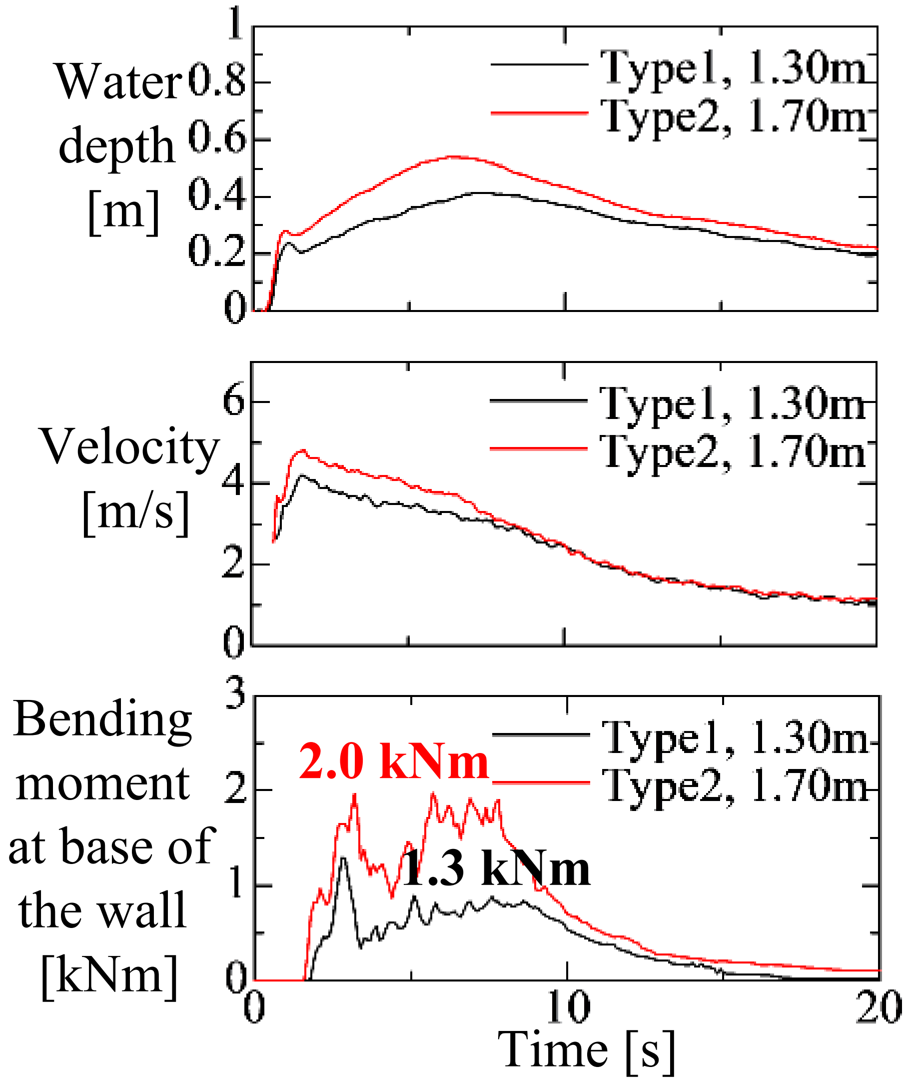
4# '',# 5$!252 8#+'5(-%%+'+-!5

NK H,7 7$#3

)%0&'(0 1#1

E 799	89* : 0/ ;<.	F.G-4>
&'(	J34 5?	D-!
	J34 5=	D-!

-74$#+'-!5-.5"1-5($' '5-.5DN>
QD-! 52 8#+'5($' 'R



E7990	89* :0/;<.	H7I46J60 G.+=4+20 6*6.+/	F7672.
&'(	J34 5?	)KD0A&6	&*+.
	J34 5=	CK(0A&6	*997<>.

Harmonic

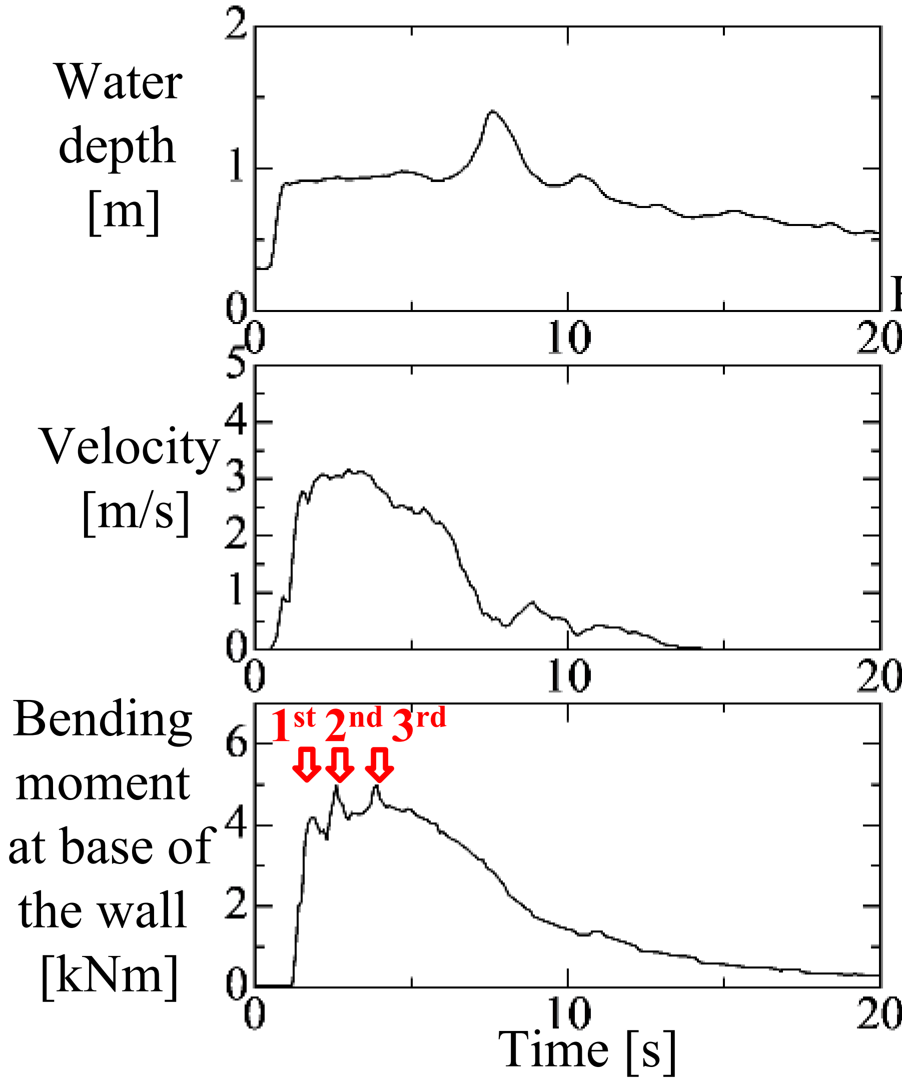
$$M_{cr} = f_r Z = \mathbf{1.5}\ \mathrm{kNm}$$

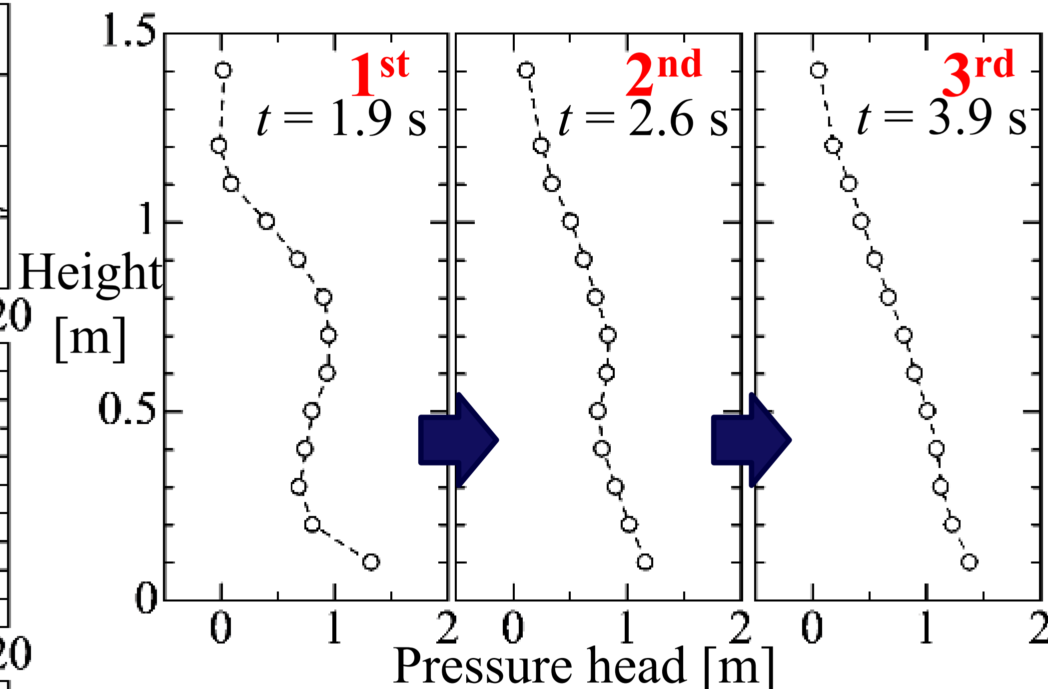
M_{cr} : Cracking moment [kNm]
f_r : Flexural strength of concrete [N/mm^2]
Z : Sectional coefficient [mm^3]

C%0&)((L0&)'(L0 &F0!)((0 1#1

E 799	89* : 0/ ; <.	F . G-4>
&)((	J34 5;	D- !
		0-%3 ")3% !
		H" %
&)'(	J34 5;	D- !
		0-%3 ")3% !
		H" %
!)((	J34 5;	D- !
		0-%3 ")3% !
		H" %

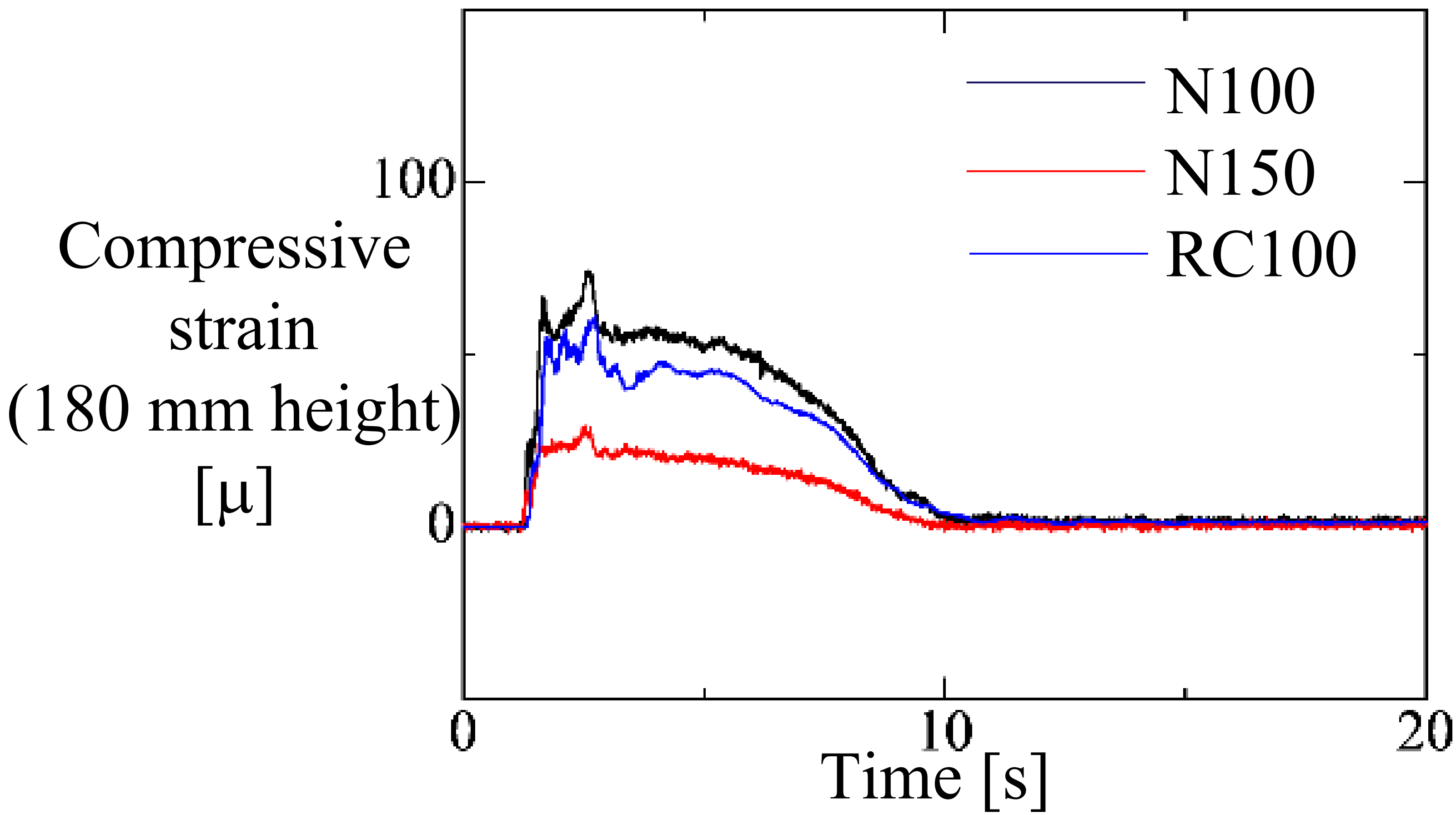
V$6 54#-.+% '5$!254# '',# 5-.5J34 5;





89* : 0/ ; <.	H7I46J60 G.+=4+20 6*6.+/07/0/3.0G7>.0 *50/3.0 : 7990?A&6@
B;<.0D	NK=

H,#.$(5(-74# ''+6 5'"#$+!5$"5?@>57 75) +9)"



?K *!"#-2,("+-!

=K /L4 #+7 !"

;K)$#$(" #+'"+('5-.51$%%5# '4-!' 5"-51$6 5

4# '',#

MK)$#$(" #+'"+('5-.51$%%5# '4-!' 5"-58-")51$6 5

4# '',# 5$!252 8#+'5(-%%+'+-!5

NK H,77$#3

Z$7$9 '5-.51$%%'

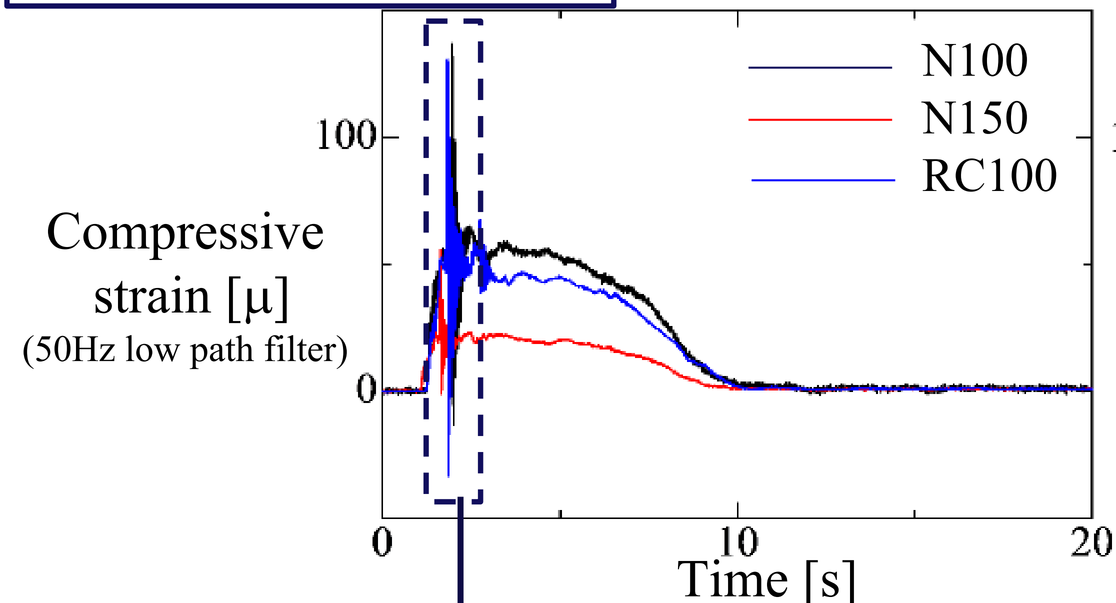
E7990/;<.	F.G-4>0/;<.	F7672.0*50:799
&)((	D-!	D-!
	0-%3 ")3% !	D-!
	H" %	-%%$4'
&)'(	D-!	D-!
	0-%3 ")3% !	D-!
	H" %	#$(G
!)((	D-!	D-!
	0-%3 ")3% !	D-!
	H" %	#$(G

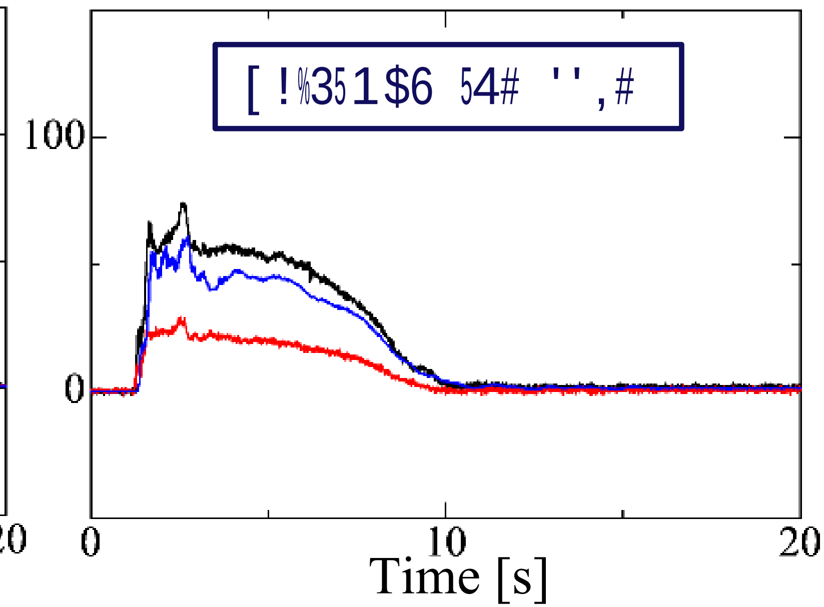
Collision speed : 0.5 m/s – 2 m/s

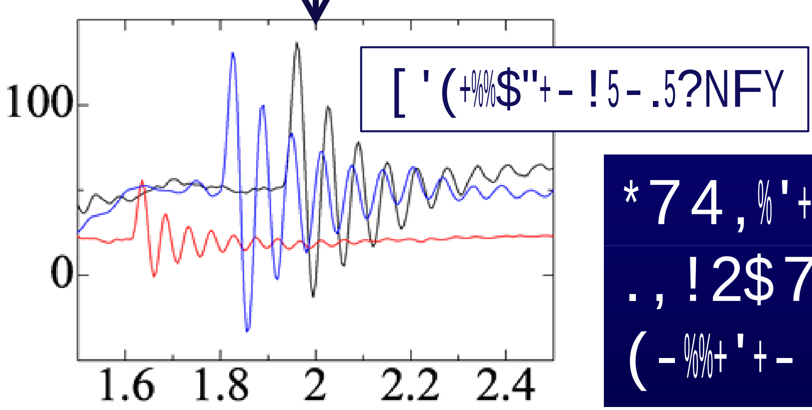
0-#5") 5($' '51+")5'" %52 8#+'B5.% L,#$%5(#$(G'5$!25 .$+%,# 5$"5") 58$' 51 # 5-8' #6 2K

H,#.$(5(-74# ''+6 5'"#$+!5$"5?@>5775) +9)"

0-%3 ")3% ! 5.-$7



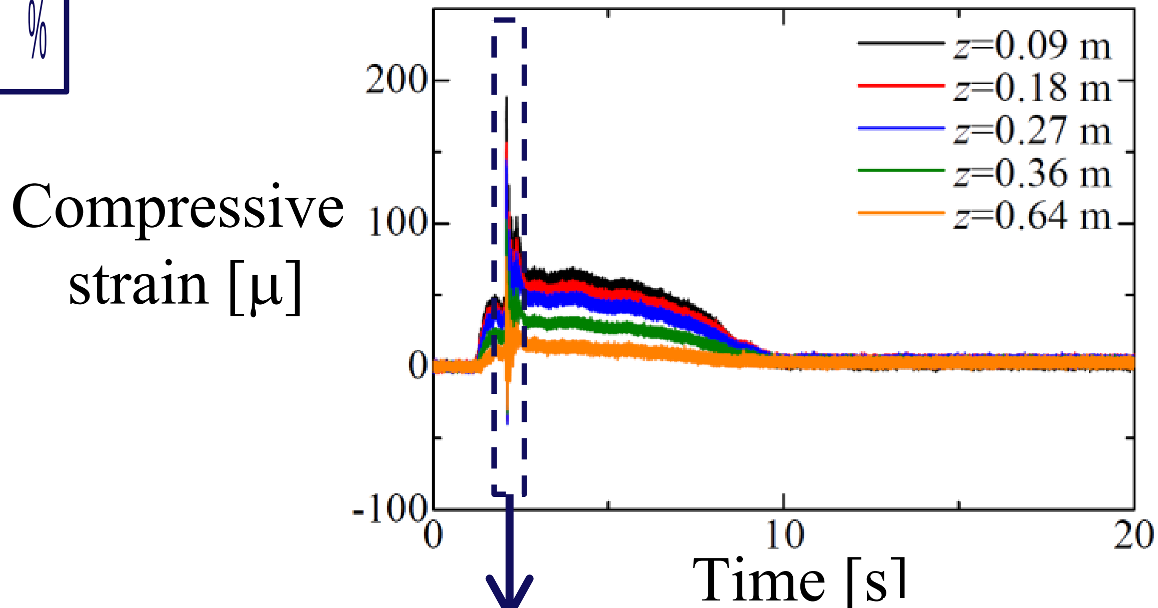


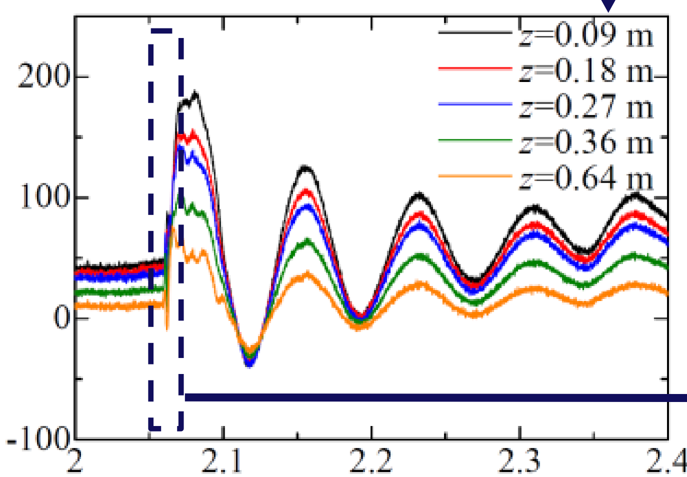


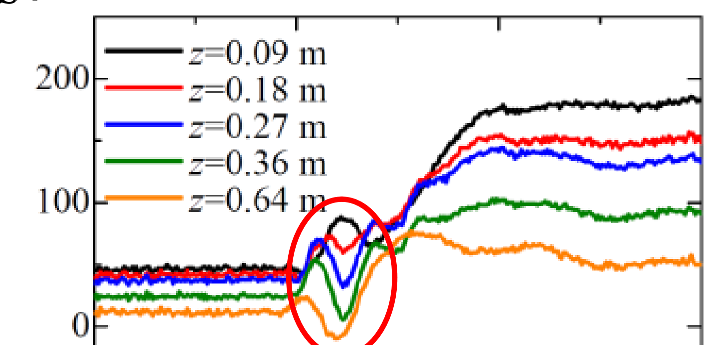
*74,%'+6 5-'(+%%$"+-!'51+")5") 5
.,!2$7 !"$%57-2 5\,'"5$." #5") 52 8#+'5
(-%%+'+-!51 # 5-8' #6 2K

H,#.$(5(-74# ''+6 5'"#$+!5-.5& ?>>

'" %







& 6 #' 54)$' 5-.5-'(+%%$"+-!51+")5;>>5FY

?K *!"#-2,("+-!

=K /L4 #+7 !"

;K)$#$(" #+'"+('5-.51$%%5# '4-!' 5"-51$6 5

4# '',#

MK)$#$(" #+'"+('5-.51$%%5# '4-!' 5"-58-")51$6 5

4# '',# 5$!252 8#+'5(-%%+'+-!5

NK H,7 7$#3

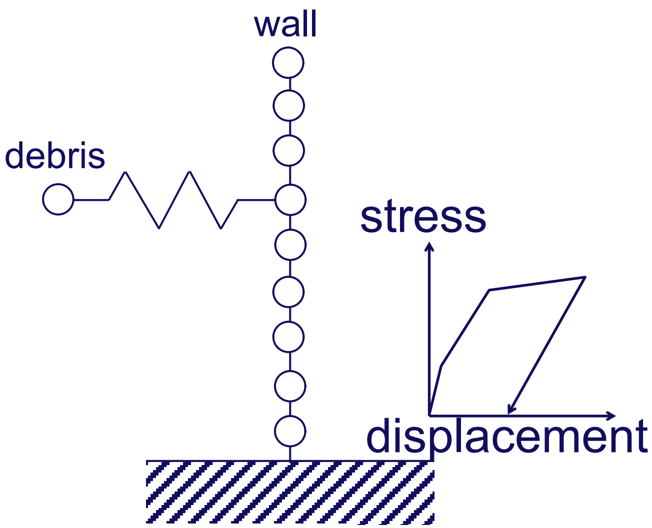
H , 7 7 $#3

- :$#9]'($% 5 L4 #+7 !"'5-!5") 5# '4-!' '5-.5 (-!(# " ^& 56 #"+($%51$%%'5"-5"',!$7+51$6 54# '',# 5$!25 2 8#+'5(-%%+'+-!51 # 5($##+ 25-,"K

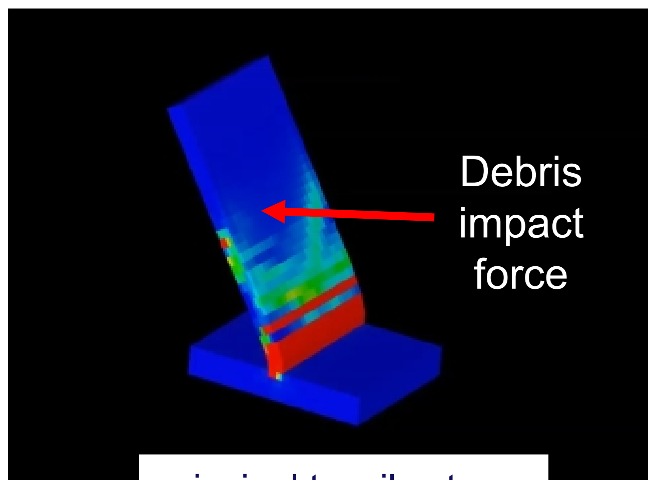
- C$\-#5# ',%"'5$# 5$'5.-%%-1'
  - _[!%35"',!$7+51$6 54# '',# `5($' '
    - O% L,#$%5.$+%,# '5$"5") 58$' '5-.5") 51$%%'51 # 5-8' #6 2K
    - J) 5(4(+"35.-#5") 5.% L,#$%5.$+%,# 5-.5(-!(# " 51$%%57$358 5$8% 5"-58 5 6$%,$" 2583 +"'5(#$(G+!957-7 !"K
  - _A-")5"',!$7+51$6 54# '',# 5$!252 8#+'5+74$("`5($' '
    - O% L,#$%5(#$(G'5$!25.$+%,# '5$"5") 58$' '5-.51$%%'51 # 5-8' #6 2K
    - +74,%'+6 5-'(+%%$"+-!'5\,'"5$." #5") 52 8#+'5(-%%+'+-!51)-' 5.# a, !(355 2 4 !2 25-!5") 57$" #+$%5-.52 8#+'51 # 5-8' #6 2K

H , 7 7 $#3

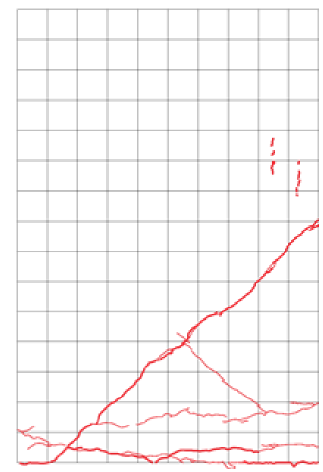
- /6$%,$"+-!5-.51$%%5# '4-!' 5"-58-")5"',!$7+51$6 54# '',# 5$!252 8#+'5(-%%+'+-!K
  - %%5-.5") 5($' '5')-1!5+!5")+'5'",23B5.% L,#$%5.$+%,# '5$"5") 58$' '5-.51$%%'51 # 5 -8' #6 2B5$!25.-#5")-' 5($' '58 $757-2 %5($!58 5,' 25.-#5") 51$%%5# '4-!' 5 6$%,$"+-!K
  - 0-#5") 5-") #5($' B5-8%+a, 5.% L,#$%5.$+%,# '51$'5-8' #6 2B5$!255.-#5',()5$5($' B5 $44%+($"+-!5-.50/C5+'5$44#-4#+$" K



Beam model



principal tensile stress solved by FEM



Trace of crack (experiment)

Shibayama, Miyagawa, Kihara and Kaida, Response characteristics and nonlinear Finite Element Analysis of RC walls subjected to tsunami wave pressure and driftage collision force, *Proc., Int. J. Offshore and Polar Eng.*, 2018. (in revision)