Abstract: KHDY\ ZDOO VWHHO PDWHULDOV 2Q

-)(6WHHO KDV EHHQ SURGXFLQJ WKH VSUHDG GDPDJH GXH WR ÀDQJH EHDP HQG F

H-shapes and pipes by applying thermo-mechanical the 1995 +\RJR .HQ 1DQEX (DUWKTXDNH

control process (TMCP) technology using the most advanced on-line accelerated cooling system in order to meet customers' needs while considering various design methods and construction technologies for high-rise buildings. This paper introduces the overview and application of representative JFE Steel's steel products for high-rise building.

1. Introduction

The Kasumigaseki Building, constructed in 1968, ZDV -DSDQ¶V ¿UVW VXSHUKLJK ULVH EXLOGLQJ 'HVLJQ PHWK ods progressed with help from advancing techniques LQ FRPSXWHU DQDO\VLV OHDGLQJ WR WKH HVWDEOLVKPHQW RI D EDVLF JURXQGZRUN IRU UHDOL]LQJ VXSHUKLJK ULVH EXLOGLQJV Thus, computer technology and design methods con WULEXWHG JUHDWO\ WR WKH FRQVWUXFWLRQ RI WKH .DVXPLJDVHNL %XLOGLQJ $QRWKHU LPSRUWDQW FRQWULEXWRU ZDV WKH VXSSO\ of steels with improved performance and working prop HUWLHV E\ WKH VWHHO PDWHULDO PDNHUV 6LQFH WKH FRQVWUXF)

7KLV UHTXLUHV WKH XVH RI KLJK VWUHQJWK

RULJLQDO GHVLJQ 7KH GHVLJQ WULDO ZDV SHUIRUPHG E\ UHSODFLQJ WKH PHPEHUV VHFWLRQ E\ VHFWLRQ EDVHG RQ WKH VWUHQJWK UDWLRV DQG EXLOGLQJ SURSHUWLHV DIWHU WKH UHSODFHPHQW ZDV FRQ¿UPHG 7KH PHPEHU UHSODFHPHQW ZDV SHUIRUPHG LQ IRXU FDVHV IRU EHDPV LQ &DVH IRU FROXPQV LQ &DVH IRU EHDPV DQG FROXPQV LQ &DVH DQG IRU EHDPV DQG FROXPQV RQ WKH WHQWK VWRU\ DQG EHORZ LQ &DVH 2QO\ WKH WKLFNQHVV ZDV FKDQJHG LQ WHUPV RI WKH VWUHQJWK UDWLR LQ WKH UHSODFHPHQW RQO\ WKH ÀDQJH ZKHQ WKH + VKDSHV ZHUH XVHG LQ WKH EHDPV 7KH KHLJKW DQG ZLGWK RI WKH VHFWLRQV ZHUH OHIW XQFKDQJHG

Table 4 shows the weight of the steel materials after

WKH GHVLJQ WULDO 7KH WRWDO VWHHO PDWHULDO ZHLJKW UHODWLYH WR WKH RULJLQDO GHVLJQ GHFUHDVHG E\ LQ &DVH E\ LQ &DVH DQG E\ LQ &DVH ,Q WHUPV RI WKH NLQGV RI PHPEHUV WKH VWHHO PDWHULDO ZHLJKW GHFUHDVHG E\ IURP WKH RULJLQDO GHVLJQ ZKHQ WKH FROXPQV ZHUH UHSODFHG E\ ZKHQ WKH EHDPV ZHUH UHSODFHG LQ DOO VWRULHV DQG E\ ZKHQ WKH EHDPV ZHUH UHSODFHG RQ WKH WHQWK VWRU\ DQG EHORZ

Table 5 shows the primary natural periods of the

EXLOGLQJ LQ HDFK FDVH &RPSDUHG WR WKH RULJLQDO GHVLJQ WKH QDWXUDO SHULRG LQFUHDVHG VLJQL¿FDQWO\ LQ &DVH DQG &DVH ZLWK UHSODFHPHQW RI WKH EHDPV DQG LQFUHDVHG OLWWOH LQ &DVH ZLWK UHSODFHPHQW RI WKH FROXPQV ,Q &DVH ZLWK UHSODFHPHQW RI WKH FROXPQV DQG EHDPV RQ WKH WHQWK ÀRRU DQG EHORZ WKH YDOXHV ZHUH PLGZD\ EHWZHHQ WKH YDOXHV LQ &DVH DQG &DVH

Figure 2 shows the story drift

DQJOHV RI WKH EXLOGLQJ LQ WKH ¿UVW VWDJH GHVLJQ DQG VHFRQG VWDJH GHVLJQ EDVHG RQ WKH RULJLQDO GHVLJQ LQ ZKLFK WKH VWRU\ GULIW DQJOH LV ,QFLGHQWDOO\ WKH RFFXUUHQFH RI HDUWKTXDNHV LV SUHVXPHG WR EH YHU\ UDUH LQ WKH VHFRQG VWDJH GHVLJQ ,Q &DVH DQG &DVH ZLWK UHSODFHPHQW RI WKH EHDPV WKH VWLIIQHVV GHFUHDVHG UHPDUNDEO\ LQ WKH XSSHU VWRULHV $W WKH VHFRQG VWDJH GHVLJQ WKH VWRU\ GULIW DQJOHV RI WKH PLGGOH DQG XSSHU VWRULHV LQFUHDVHG E\ PRUH WKDQ IURP WKH RULJLQDO GHVLJQ WKXV PDNLQJ LW LPSRVVLEOH WR PHHW WKH GHVLJQ FULWHULD ,Q &DVH ZLWK replacement of the columns, a design change was thor

RXJKO\ SRVVLEOH 7KH GHVLJQ FRQGLWLRQV ZE RPR 7R 5 1 0ÀRQV `R` PL

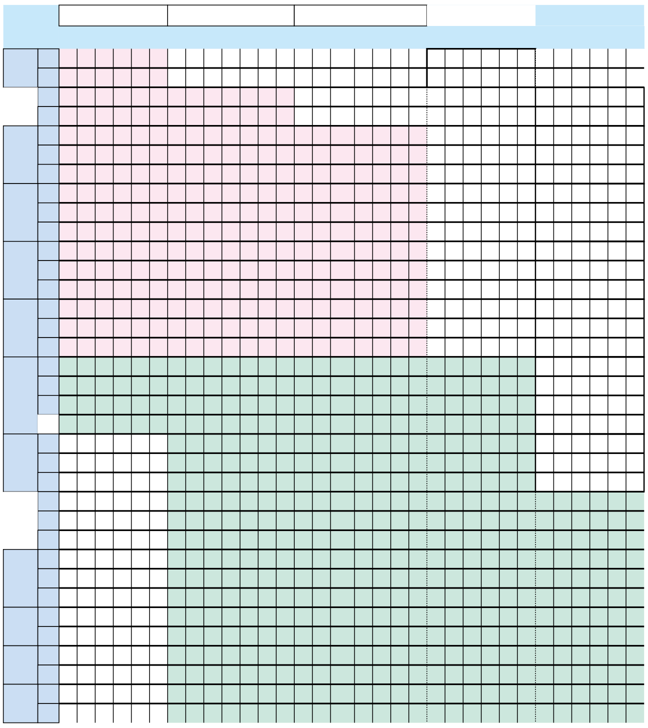
SURGXFWLRQ XS WR 0DUFK +%/ ZDV DSSOLHG WR DERXW WXLOGLQJV 7KH FXPXODWLYH VKLSSLQJ TXDQWLW\ during this period reached 25 W $V DQ H[DPSOH more than 5 W RI +%/ ZDV DGRSWHG IRU ER[FRO XPQV LQ WKH *UDQ 7RN\R 1RUWK 7RZHU VWDJH , QXPEHU RI VWRULHV EHORZ JURXQG; penthouse, 2 WR RULHV PD[LPXP KHLJKW DERXW P Photo 1 DQG *UDQ 7RN\R 6RXWK 7RZHU QXP EHU RI VWRULHV EHORZ JURXQG SHQWKRXVH PD[LPXP KHLJKW DERXW P

2.1.2 High-weldability 590 N/mm^2 steel material (SA440-U)

7KH FRQYHQWLRQDO IRU EXLOGLQJ 6$ KDV D KLJK $FP DQG &eq RQ HTXLYDOHQW high content of P_{CM} D FRPSRQHQW KLJKO\ VXVFHSWLEOH WR ZHOGLQJ FUDFNV +HQFH WKHUH ZHUH PDQ\ UHVWULFWLRQV RQ SUHKHDWLQJ DQG EHDG OHQJWK ZLWK WKLV PDWHULDO 7KH KLJK ZHOGDELOLW\ 6$ 8 KDV VXE VWDQWLDOO\ LPSURYHG ZHOGDELOLW\ WKDQNV WR DQ RSWLPXP composition design and a special heat treatment for

DQG 7UDQVSRUW DQG WKH\ DOVR UHDOL]H KLJK &KDUS\ DEVRUS
WLRQ HQHUJ\ LQ Table 7 Chemical compositions of the steel grades
PHFKDQLFDO SURSHUWLHV RI WKHVH VWHHO JUDGHV
+%/ (+%/ (+%/ (DQG 6$ (
FDQ EH ZHOGHG DV HDVLO\ WKDQ VWHHO PDWHULDOV XQWUHDWHG
E\ WKH XVXDO ODUJH KHDW LQSXW PHDVXUHV LI QRW PRUH HDV
LO\ 7KXV WKH\ FDQ EH ZHOGHG XQGHU WKH VDPH SUHKHDWLQJ
FRQGLWLRQV)RU 6$ (WKH FRPSDQ\ KDV GHYHORSHG
D OHZ 6$ (JUDGH WKDW FDQ EH ZHOGHG DV HDV
LO\ DV WKH KLJK ZHOGDELOLW\ 6$ % 8 DQG 6$ & 8
GHVFULEHG LQ WKH SUHFHGLQJ VHFWLRQ

2.2 Thick-Wall, High-Strength Steel Materials



+ VKDSH LV D KRW UROOHG + VKD
DQG ÀDQJHV ZLWK D SODWH WKL
VWHHO SODWH VHULHV 2XWVWDQ
DFFXUDF\ DUH DVVXUHG LQ LWV
GLPHQVLRQV RI 6XSHU +LVOHQG
VDPH VKDSHV DV EXLOW XS + VKD
ZHOGLQJ VWHHO SODWHV WRJHWK
+ VKDSHV PDNH LW SRVVLEOH WR
HFRQRPLFDOO\ LQ WKH EXLOGLQJ
Photo 3 VKRZV WKH 'HQWVX %XLO
EXLOGLQJ LQ ZKLFK 6XSHU +LVOHQ
DV DQ H[DPSOH /DUJH VL]H 6XSH
XVHG LQ WKH EHDP PDWHULDOV

2.3.2 Heavy gauge H-shapes

+HDY\ JDXJH + VKDSHV ZLWK ÀD
H[FHHGLQJ PP KDYH ODUJH VHFWLRQV
WKRVH RI ER[FROXPQV DVVHPEOHG E
WRJHWKHU 7KH\ DUH LGHDO IRU XV
IRU KLJK ULVH EXLOGLQJV DV WKH\
MRLQWV WKDQ ER[FROXPQV DQG RI
LPSURYHG VDIHW\ DQG VKRUWHU PDQ
-)(6WHHO GHYHORSHG WKH KHDY
î VHULHV DV FROXPQ PDWHULD
designs. 7KHVH VHULHV KDYH RXWVWDQ
developed earlier, and their sectional performance in
Figure 4 shows the
(Photo 4

Table 10 Mechanical properties of low yield strength steel

Grade	Plate /Pipe	Tensile test				
		< 6 1 P^{2}P)	7 6 1 P^{2}P)	< 5	(O	Y (Û & (J)
-) (/<	Plate	±	±	”	•	•
-) (/<		±	±	”	•	•
-) (/<	6 Pipe	±	±	”	•	•
-) (/<	6	±	±	”	•	•

<3 <LHOG SRLQW 6 < 5 (O (ORQJDWLRQ Y(Û& &KDUS\ DEVRUEHG HQHUJ\ DW Û&

2.4 Low-Yield-Point Steel Materials

/RZ \LHOG SRLQW VWHHO PDWHULDOV DUH XVH LQ YLEUDWLRQ FRQWURO GHYLFHV WKH UHVSRQVH RI VWUXFWXUHV WLDOO\ GLVVLSDWLQJ WKH HDUWKTXDNH 7KH\ KDYH EHHQ LQVWDOOHG LQ GDUG VLQFH WKH +\RJR .HQ 1DQEX -)(6WHHO KDV D OLQHXS RI point steel materials (Table 10 7KH -)(6WHHO GHYHORSHG WKUHH W\SHV RI YLE EUDFH W\SH WKH DVVHPEOHG W\ GDPSHU SURGXFWV 7ZR W\SHV WKH WXEH LQ WXEH W\SH EXFNOLQ OHVV WXEH -)(/< 6 RU -)(/< D[LDO PDWHULDO DQG WKH ÀDW EDU W\SH E\ D VTXDUH VWHHO WXEH LQ ZK SODWH -)(/< RU -)(/< material (Fig. 5 Figure 6 compares the restoring char

DFWHULVWLFV EHWZHHQ D FRQYHQW WKH GHYHORSHG GDPSLQJ EUDFH EUDFH LQ ZKLFK FRPSUHVVLRQ DQG IRU ERWK VWLIIQHVV DQG \LHOG VW characteristics and a high plastic deformation capacity

2.5 Welding Techniques

$V EXLOGLQJV EHFRPH ODUJHU PR RQ HI¿FLHQF\ IRU HDVH RI ZHOGLQJ - 67$5:HOGLQJ ® LV D &2 arc welding method using a wire with an appropriate amount of rare earth metal added and electrode negative polarity in place of the conventional electrode positive mode[13,14]. :LWK WKLV welding method, arc and plasma forms in the shape of a ... the droplet transferred from the tip of the wire to the ...

3. Conclusions

$V DQ LQWHJUDWHG LURQ DQG V