Analysis of the Influencing Factors on the Load-deformation Skeleton Curves of PDCB

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Abstract—In the frame-shear wall structure（FSWS）of reinforced concrete, the coupling beam ofshear wall(CB)and frame beam(FB) up the corresponding part of which has a stage of workingcooperatively under horizontal load.However,the research on the whole working mechanism of the CB and FB under that stage is little.By taking parallel double coupling beam(PDCB) with different width (PDCBDW) which is constituted of the CB and FB as research object, the loading process of 11PDCBare simulated under low-cycle repeated load by nonlinear finite element software. The results show that: with the increase of span-depth ratio of the FB, the yield load(YL)andultimateload(UL)decreases,the yield displacement(YD), ultimate displacement(UD) and ductility factor(DF) increases. With the decrease of span-depth ratio of the CB, it presents rebound phenomenain skeleton curve.With the increase of the section width of the FB,the YL, UL and DF increase. With the increase of concrete strength，the YL and UL increases. With the increase of the reinforced area ratio, the YL and UL increase. This implies that the span-depth ratiois an important factorwhich influences the skeleton curve.

Keywords-Double Coupling Beams; Load-deformation; skeleton curve; influencing factor; yield displacement

I. Introduction

In reinforced concrete frame-shear wall structure (FSWS),there are parallel double coupling beams (PDCB) with different size, which is composed of part of frame beam (FB) and coupling beam (CB)of shear wall in FSWS. In shear wall structure, there are also PDCB, which is composed of two coupling beams with the same width. But these two kinds of PDCB are different not only because the width of the beams is different, but also because the reinforcement requirement of them is also different[1]. Many different kinds of CB are promoted by different researchers through changing reinforcement arrangement, taking new structure measurement or changing materialetc, and much research work is also done on them accordingly[2-5]. But little study is done on the PDCB in FSWS. Therefore, it becomes one of the focuses of civil engineers on how the force behavior of parallel double coupling beams with different widthis [6]. So, in this paper, thefactors which influenced the skeleton curveof the load-displacement will be analyzed.

II. Designed Specimens

The factors that influence the mechanical properties of PDCB mainly includes the span length(SL) of the CB and the FB, the section height(SH), the section thickness(ST),the span-depth ratio(SDR) of the beams, the concrete strength(CS) and the reinforced area ratio(RAR) which is the area ratio of longitudinal reinforcement in the CB and the FB. In order to analysis the influence on theskeleton curvesof load-deformation(SCLD) of these factors,11 specimensare designedshown in Table1. The longitudinal tensile bar of the CB and the FBare all HRB335,at the same time, the stirrup of them are all HPB300.

TABLE I. LIST OF THE SPECIMENS

No	FB				CB				CS	RAR
	SL (mm)	SH (mm)	ST (mm)	SDR	SL (mm)	SH (mm)	ST (mm)	SDR		
1	1200	800	300	1.5	1200	400	200	3	14.3	2
2	1200	480	300	2.5	1200	400	200	3	14.3	2
3	1200	600	300	2	1200	400	200	3	14.3	2
4	1200	600	300	2	1200	800	200	1.5	14.3	2
5	1200	600	300	2	1200	550	200	2.2	14.3	2
6	1200	600	400	2	1200	400	200	3	14.3	2
7	1200	600	250	2	1200	400	200	3	14.3	2
8	1200	480	300	2.5	1200	400	200	3	C25	2
9	1200	480	300	2.5	1200	400	200	3	C35	2
10	1200	480	300	2.5	1200	400	200	3	C30	2.5
11	1200	480	300	2.5	1200	400	200	3	14.3	1.5

III. FINITE ELEMENT SIMULATION METHOD

In order to simulating the load-bearing process of PDCB, blocksare set at both of the beam ends to make it easy to apply low cyclic load, shown as Fig .1. The loading process of the PDCB is simulated by finite element software.In simulation: the stress-strain curve of the concrete is plastic damage model;eight-node reduced integration of the three-dimensional solid elements(C3D8R)are used to simulate the concrete and upper and lower blocks. TRUSS elements are used to simulate steel. The "embedded" is used to simulate the contact between steel and concrete [7-10].The lower block is consolidated by limiting displacement of all-directions. The vertical displacement and internal and external plane rotation of the upper block is limited, which makes it can solid along horizontal direction.Ant-symmetric low cyclic loading is applied on both ends of the upper block.Newton-Raphson iteration methodis adoptedto solve the problem.The finite element model is shown as Fig .2.

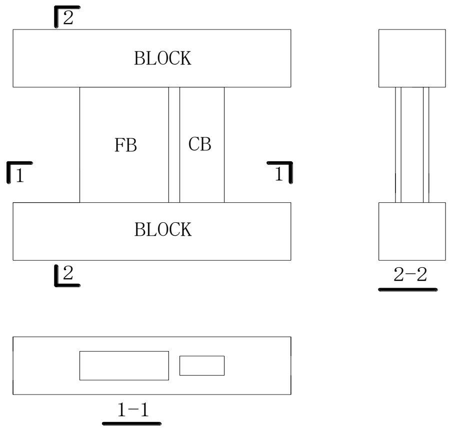

Figure 1. designed PDCB

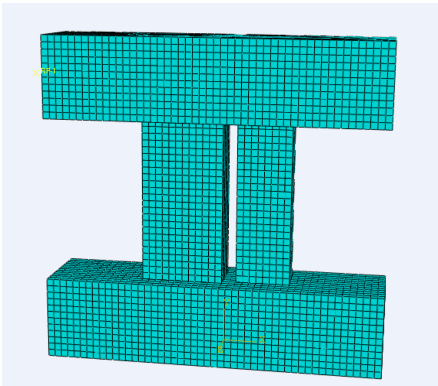

Figure 2. Finite element model of PDCB

IV. ANALYSIS OF INFLUENCING FACTORS ON LOAD-DEFORMATION SKELETON CURVES

In order to analyze the factors that influence the PDCB,the skeleton curvesof specimen arecalculatedand the key parameters such as the yield load, theultimateloadand ductility factor are also calculated according “The General Yield Moment Method”[11-13]. The skeleton curves are shown as Fig .3 toFig .7.

A. *Influence of the span-depth ratioα*

The skeleton curves of specimensnumbered 1,2and3 are shown in Fig .3,of which thespan-depth ratio of the FB is changed.It can be seen from the figures, when the span-depth ratio changes from 1.5 to 2.5, the yield load(YL) and the ultimate load(UL) all decreases by about 47%, the yield displacement(YD)and the ultimate displacement(UD) increases by about 18% and 22% respectively, the ductility factor increases 5%. It shows that with the increase of span-depth ratio of the frame beams, the YL and the UL decreases, the YD, the UD and ductility factor increases.

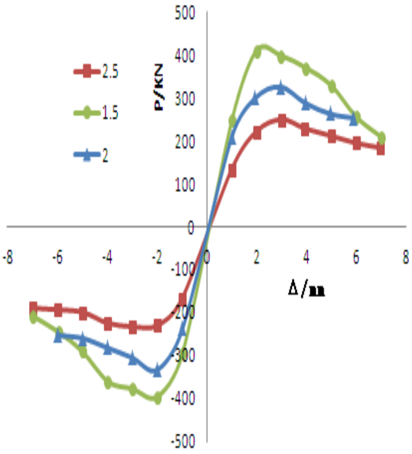

Figure 3. The influence of αtotheP-ΔSkeleton curves

B. *Influence of span-depth ratioβ*

The skeleton curves of specimensnumbered 3,4and5 are shown in Fig .4,of which thespan-depth ratio of the CB is changed.It can be seen from the figures, when the span-depth ratio changes from 1.5 to 3, the YL increases by about 5% and the ULincreases by about18%, the YDdecreases by about 15% and the UD increases by about 23% after the first decrease by about 20%, the ductility factorincreases by about 32% after the first decrease by about 26.6%.From this we can conclude that with the decrease of span-depth ratio of the CB, the YL and UL increases, the YD decreases,the UD and the ductility factor increases after the first reduction, which exhibits rebound phenomena on skeleton curve.

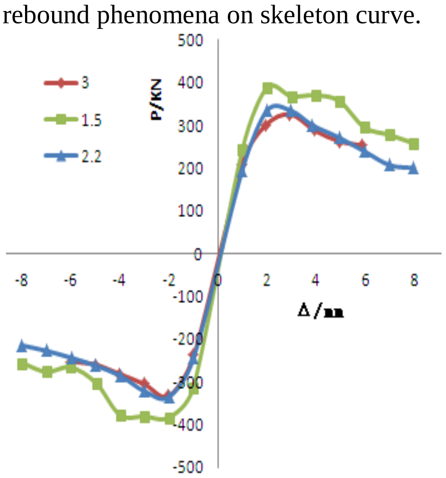

Figure 4. The influence of βtotheP-ΔSkeletoncurves

C. *Influence of the section width B*

The skeleton curves of specimensnumbered 6,3and7 are shown in Fig .5, of which thesectionwidth of the FB is changed.It can be seen from the figures, when the sectionwidth changes from 250 to 400, the YL and the UL decreases by about3% and 6% respectively, the YD and the UD decreases by about 10% and 33% respectively, the ductility factordecreases by 33%. It shows that with the increase of the section width of the FB,the YL, the UL and the ductility factor increases, the YD and the UD decreases.

D. *Influence of concrete strength fck*

The skeleton curves of specimensnumbered 8,10 and 9 are shown in Fig .6, of which theconcrete strength is changed.It can be seen from the figures, when the concrete strengthchanges from 25 to 35, the YL and the UL all increases by about 12% of, the YDincreases by about 9%,the UD decreases by about 6% after the first increase by about 9%, the ductility factor decreases by about 14% after the first increase by about 11%. It shows that with the increase of the concrete strength,theYL and UL increases, the UD and ductility factor decreases after the first increase.

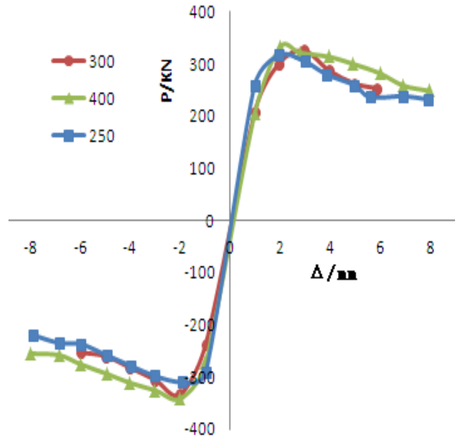

Figure 5. The influence of B totheP-ΔSkeleton curves

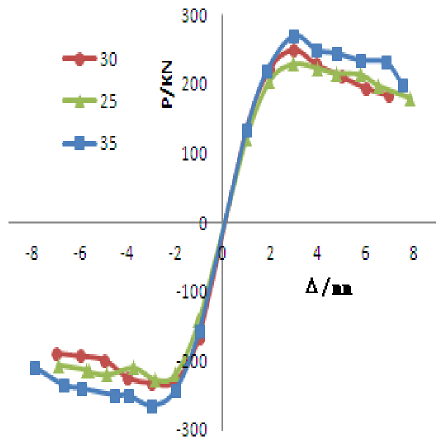

Figure 6. The influence of fckto Skeleton curves

E. *Influence of reinforced area ratios.*

The skeleton curves of specimensnumbered 11,2 and 10 are shown in Fig .7, of which theconcrete strength is changed.It can be seen from the figures, when the reinforced area ratiochanges from 1.5 to 2.5, the YL and the UL all decreases by about10%, the YD is almost unchanged, the UD andthe ductility factor all increases by about 15%, and in the descending stage,the bearing capacity reduces slowly with the increase of the reinforced area ratio. It shows that with the increase of the reinforced area ratio, the YL and the UL has all increases, the YDis almost unchanged, the UD decreases and the ductility factor reduces.

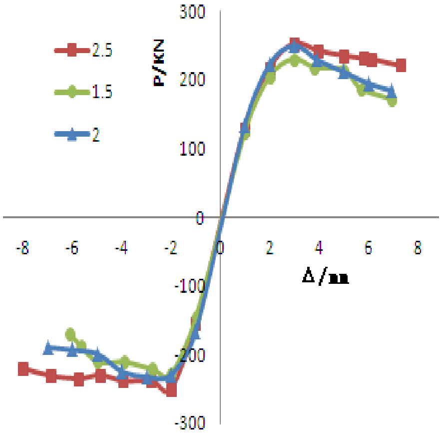

Figure 7. The influence of sto Skeleton curves

V. SUMMARY

Based on the above analysis, the following conclusions can be drawn:

With the increase of span-depth ratio of the FB, the YL and UL decreases, the YD, the UD and ductility factor increases.With the decrease of span-depth ratio of the CB, the YL and UL has increases, the YD decreases, the UD and ductility factor increases after the first reduction.

With the increase of the section width of the FB, the YL, UL and ductility factor increases, the YD and the UD decreases.

With the increase of the concrete strength, the YL, UL increases, the UD and ductility factor decreases after the first increase. With the increase of the reinforced area ratio,the YL and the UL all increases, the YDis almost unchanged, the UDand the ductility factor decreases.

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