The Study on Flexural Capacity of Bolt Connection of Steel Sheet Pile of H + Hat Combination in Experiment

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Abstract: Steel sheet pile of H + Hat combination is welded by domestic H-type pile and wide Hat-type pile imported from Japan,that is simple structure,excellent flexural stiffness and economically repetitious usage.Because of these advantages,it has extensive application prospect.But in the traditional fillet welding,there is some inconvenience on the stage of first connecting and late repeated using.In order to make some improvement,the experimental way is adopted to study the bolt connection of H + Hat combination steel sheet pile,especially its mechanical properties,bending deformation and the coupling of H-type pile between wide Hat-type pile.The results of this experimental show that the midpoint deflection of steel sheet pile of H + Hat combination,which is connected by the bolt,satisfies the requirement of deformation;with the bolt connection,the coupling of H-type pile between wide Hat-type pile is very good and their micro-strain between each other is also tiny,that can well satisfy the engineering application.

Introduction

In recent years, China's infrastructure projects make a development by leaps and bounds, especially in cities, which are gradually developing into three-dimensional space like the air, ground and underground. At present, the foundation pit engineering is the most direct and effective way to forming underground space, the common methods used in supporting pile brace of foundation pit include numerous supporting scheme, like putting the excavation spray anchor, pile brace, drilled grouting pile, SMW-method, Larsen steel sheet pile, cement-soil retaining wall, underground diaphragm wall and so on. Combination of steel sheet pile is welded by the large size of hot-rolled wide Hat-type pile and all kinds of size of H-type pile [1].High strength bolt connection of steel sheet pile of H + Hat combination also has some problems, for making further improvement, it is adopted a experimental way to study of test of mechanical properties and the bending deformation of steel sheet pile of H + Hat combination welded by high strength bolt connection.

Test program

The selection of size of steel sheet pile of H + Hat combination and test equipment selection

In the test, it chooses 900 mm hot-rolled wide Hat-type pile (NSP-10H) produced by Japan's Nippon steel company and narrow flange Q345BH domestic steel (HN800*300).They are shown in figure 1.

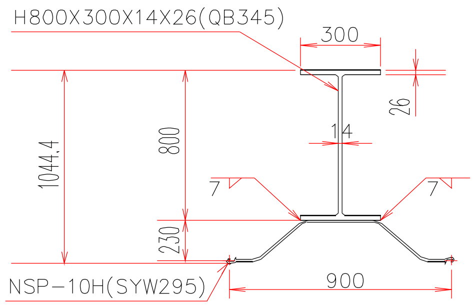

Figure 1 Test steel sheet pile section size

Connection is using high strength bolt of M24 with bilateral symmetry arrangement 10@2000,the length of steel sheet pile is 8m.The mechanical performance parameters of steel sheet pile of H + Hat bolt connection combination are shown in table 1.

Section dimensions (mm)	Effective width(mm)	Sectional area（cm^2/m）	Theoretical weight（kg/m）	Moment of inertia（cm^4/m）	Section modulus（cm^3）
800×300×14×26	900	415	326	552289	10005

Table 1 test H + Hat mechanics performance parameters of the steel sheet pile

Test scheme design

Experiment takes the method of step loading at the mid-point to complete with six times,in turn,it is 180KN,360KN,540KN,720KN,900KN and 1080KN.Strain monitoring location is located respectively at the mid-point and 1/4-point of the pile.In addition,for the observation of the coupling and relative displacement between H-type pile and Hat-type pile,so the tester sets up 10 monitoring point at the edge of H-type pile and Hat-type pile respectively.In the loading process,the total station coordinate the original firstly and then the tester continuously observe the change of the horizontal and vertical displacement.In order to detect strain differences between H-type pile and Hat-type pile,tester respectively sets up the strain gauge at the mid-point and 1/4-point of the steel sheet pile of H + Hat combination to obtain the data of strain differences.Arrangement of measuring points is shown in figure

Test project

In the process of test, the following three aspects are monitored:

(1) The coupling and relative displacement between H-type pile and Hat-type pile,which located respectively at the mid-point and 1/4-point of the steel sheet pile of H + Hat combination.

(2) Under repeated loading,the deformation differences between H-type pile and Hat-type pile at the mid-point of the steel sheet pile of H + Hat combination.

(3) The strain differences between H-type pile and Hat-type pile.

Test results analysis

Stress calculation under bending

Across the maximum deflection under a concentrated load in the span of beam,the calculation formula is $Y_{max} = pL^3 / (48EI)$.

Note: Y_{max} for maximum deflection of beam span (mm)

P:concentrated load(N)

L:the length of pile(m)

E:as the elastic modulus of steel,steel for engineering $E= 2.06 \times 10^5$ N/mm

I:steel section moment of inertia,according to the steel sheet pile test from the model of H + Hat combination of NSP-10 H 800 x 300 x 14 x 26 mm,available $I = 552289\ cm^4$

The coupling analysis of H-type pile and Hat-type pile

The displacement variance analysis of H-type pile and Hat-type pile

For understanding the coupling of H-type pile and Hat-type pile,it is now considering from the perspective of both displacement.Figure2 is shown the displacement differences of each point of H and Hat when the load is added to 900KN.

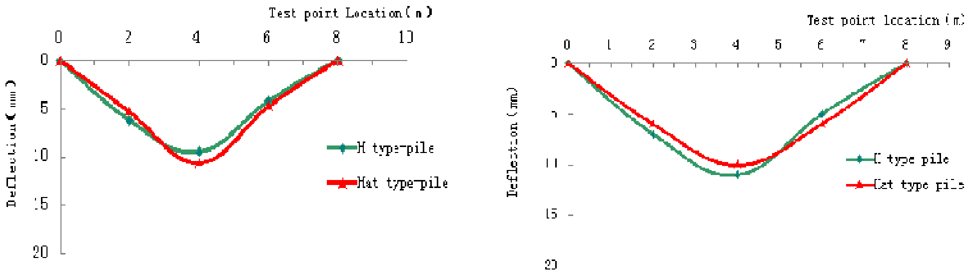

Figure2 H and Hat deformation difference when loaded to900KN and1080KN

From figure2.You can see that the deformation differences between H and Hat is different in different position,the maximum difference is 1.2mm at the mid-point,the displacement difference of the two is 0.9 mm at the 1/4-point. Because of the high strength bolts instead of welding in this process,the coupling of H and Hat is better. Although displacement appears under this circumstance,it is so tiny that the requirements of deformation can be satisfied.

To verify the deformation difference under extreme pressure condition,it will add load strength to1080KN which is the limit pressure for test condition.Under this pressure condition,the deformation differences of H and Hat are shown in figure4.

You can see from figure4,H and Hat deformation of each point both differences and 900KN were similar.It is still good,can better finish the work together.

The midpoint deflection under repeated loading

By the two cases of 900 KN and 1080 KN we can see,H-type pile and Hat-type pile of in the process of loading step by step,the deformation of the difference is small,and the maximum deformation differences appear in the midpoint,so you need to repeat this with the most unfavorable position midpoint,and validation of H-type pile and Hat-type pile deformation difference between.

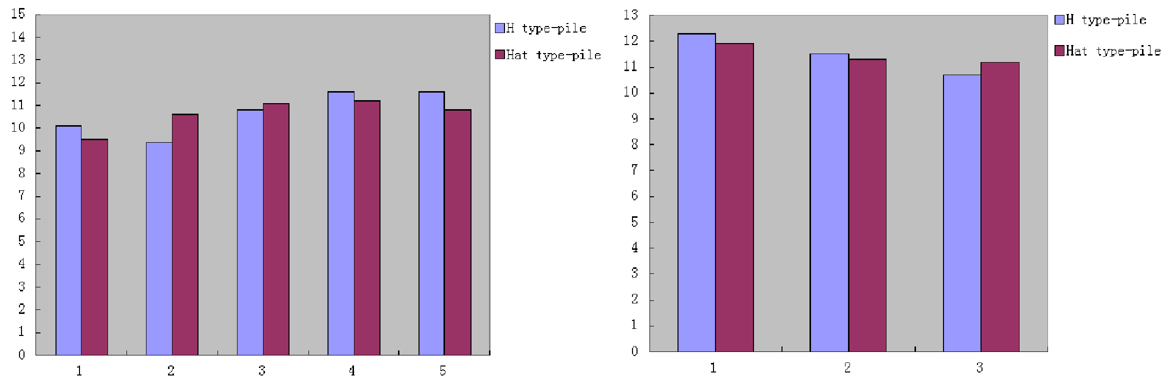

Figure3Midpoint reloading 900KN five times on the H+Hat and the contrast

You can see from figure4, five repeated load of 900 KN, H-type pile and Hat-type pile displacement difference is the average of the two, the biggest difference is 1.2mm,the minimum value is 0.3mm, with a mean of 0.66mm. From this we can see both under the action of repeated,deformation difference is small,the coupling is better.

When loading to 1080KN,both the displacement difference is not big,still the biggest difference is 0.5 mm,with a mean of 0.34 mm.Can do together, coupling is better.

H-type pile and Hat-type pile micro-strain differences

Micro-strain test results and calculation formula

Instrument coefficient of standard: G =3.70με/Digit (Digit $=f^2 x10^{-3}$,f for strain gauge frequency).

The average correction coefficient C:1.008369;Rate using BGK408 reading meter(C: 400-1200HZ).

Formula:ε (micro strain)=G C (R_1 - R_0): R_0 for initial readings,R_1 for current readings.

To the measured data in formula,the calculation results are as follows:

Table 2 step by step loading point and 1/4 strain values

Load moment KN*m	The strain on H midpoint	The strain on Hat midpoint	The strain of H At one-fourth	The strain of Hat At one-fourth
360	63.43	140.09	54.66	75.93
540	168.64	310.23	65.85	118.46
1080	275.53	496.03	88.98	154.46
1440	414.14	593.97	127.11	174.61
1800	607.78	678.85	162.67	208.75

Micro-strain test results analysis

From table2 can be concluded as shown in figure 5 h-beam and Hat strain differences both in the midpoint.

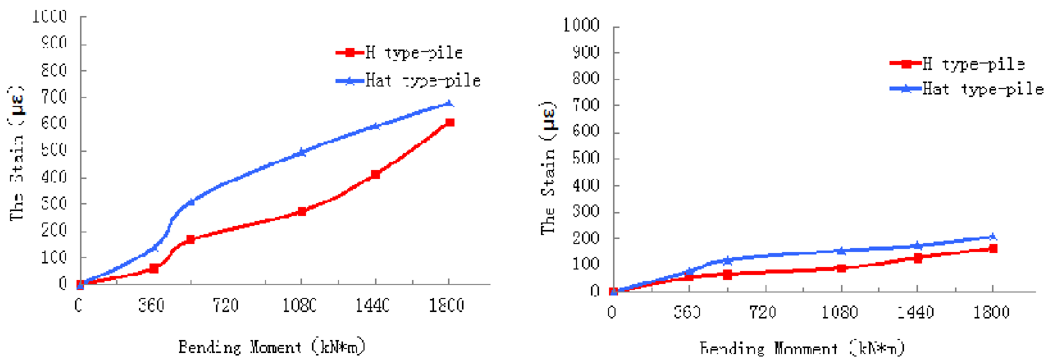

Figure 4point bending moment under the change of strain between H and Hat

You can see from figure 5,with the increase of load moment,h-beam and pile cap of Hat at the midpoint of basic linear strain increased.In the process of loading step by step between H and Hat,under the bending moment value strain difference is smaller.Therefore, when bending moment increased,h-beam and pile cap of Hat in the midpoint of the strain difference is small.It is better, in the high strength bolt connection, both can do together,and the alignment is good.

Conclusion

(1) In the process of step-by-step loading on the bolt connection of steel sheet pile of H + Hat combination,the deformation difference between H-type pile and Hat-type is very tiny,even at the mid-point which the deformation difference is the largest,the maximum value is only 1.2 mm.It shows that the deformation of both is basically the same and the coupling of both is also very matched,so the bolt connection can make H and Hat piles work together better.

(2) In 900KN loading condition,it is repeatedly put on the bolt connection of steel sheet pile of H + Hat combination for five times.The results show that the maximum value of deformation is 1.2mm,the minimum value is 0.3 mm and the average value is 0.66mm.While in 1080KN loading

condition, it is repeatedly put on the bolt connection of steel sheet pile of H + Hat combination for three times.The results show that the maximum value of deformation is 0.5mm and the average value is 0.34mm.Even at the mid-point which is the worst testing location, the deformation difference of both is very tiny within the allowable range.The better coupling of H and Hat also well meet the engineering requirements.

(3) In the process of step-by-step loading on the bolt connection of steel sheet pile of H + Hat combination,the micro-strain difference between 1/4-point and mid-point is very tiny.It shows that H-type pile and Hat-type pile can jointly complete deformation and forcement with each other,and also realize good coupling with H and Hat under the bolt connection.

(4) It is very convenient for steel sheet pile of H + Hat combination to disassemble.After the construction, the damaged H-type pile or Hat-type pile caused by deformation of the steel sheet pile of H + Hat combination can be better separated.Therefore,it is easy to facilitate and assemble again with other size of H-type pile and Hat-type pile with the bolt connection.

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