

EFFECT OF CONFINED REINFORCEMENT ON DEVELOPMENT OF HIGH YIELD STRENGTH DEFORMED (HYSD) BARS

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ABSTRACT

The practice of using reinforcement in concrete is one of the most effective methods used in construction from very long time. IS code have many things to utilize while designing the structure for sound and better stability and selection of the material is one of them. Concrete is one of the most important material for construction of various structures and it exists in various grades like M20, M25, M30 etc where 'M' represents mix design value and the succeeding number indicates strength of concrete in MPa. For providing reinforcement to concrete steel bars are used which comes in different grades like Fe250, Fe415 and Fe500. These bars provide greater tensile strength to structure and ultimately improves stability and life of structure.

In this report an attempt is made to identify the effect of hook shapes on development length, percentage of confined reinforcement in compression on bond strength. The change in shape of hook ultimately provides different values of bond stress with different grade of concrete to be used.

Keywords: Bond Strength, Development Length, Lap Splices

1. INTRODUCTION:

The term 'bond' in reinforced concrete refers to the interaction between the reinforcing steel and the surrounding concrete. Proper bond between steel and concrete ensures that there is no slip between steel bar and concrete under service load. For many years, bond stress was considered in terms of shear stress at the interface between reinforcing bar and concrete.

The Indian codal provision was revised in year 2000, still the development length provisions remains unchanged and it does not cover the effect of several other parameters whereas US codal provisions considered all this parameters. Hence, the provisions of the Indian code are discussed in this topic. The common assumption in Reinforced concrete is that plane section remains plane after bending will be valid only if there is proper bond between steel and surrounding concrete.

The development length is a certain minimum length of the bar and it has to be provided on either side of point of maximum steel stress to prevent the bar from pulling out under tension. When the sufficient development length is not provided then in practical situations bends, hooks and mechanical anchorages can be used.

2. LITRATURE REVIEW

Many studies and experiments are carried out on development length of tension and compression side of the bar. **Mohamed H. Haraji and Bilas S. Hamad (2004)** studied the effect of confinement of bond strength between reinforcing steel and concrete. They concluded that for small development length, the concrete confined with local bond conditions has slightly increases the bond strength. The bond strength due to confinement increases in proportion to modulus of elasticity of confining material which is not depend upon yield strength of the material. **Tharman and T Kaku (2013)** studied the development evaluation of reinforcing concrete beam with CFRP Bars. It is then concluded that the anchorage length in hanging support of reinforced concrete beam, the use of CFRP will be having high tensile strength and no plastic behavior. Additional length of embedded bar has significant influence on increasing capacity of the beams. **David Darwin et.al (2017)** had discovered that there is significant difference between the clear spacing between bars and concrete covers indicates that the bar force increases in linear but non proportional manner, hence the required development length must be increased more rapidly as per steel stress values.

3. TESTS ON MATERIAL:

For the further experiment various materials like cement, sand, aggregate and water is used and various tests are performed to check quality of material. Following data shows results.

3.1 Tests on Aggregate:

Sr.No	Material	Specific Gravity	Fineness Modulus
1	Coarse Aggregate	2.9	7.01
2	Fine Aggregate	2.6	2.94

3.2 Tests on Cement:

Sr.No	Tests Performed	Values
1	Fineness Of Cement	7.25 %
2	Standard Consistency	33 mm
3	Initial Setting Time	45 Min
4	Normal Setting Time	580 Min

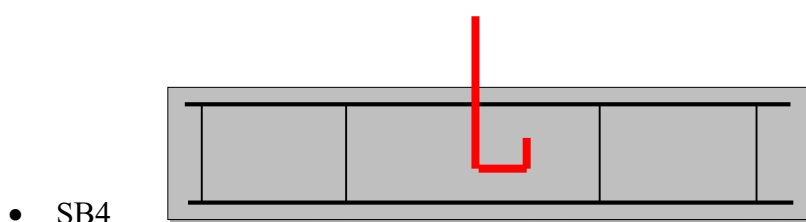
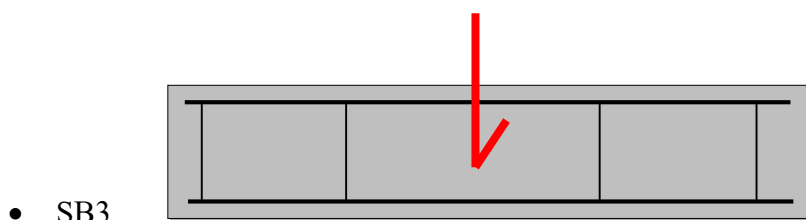
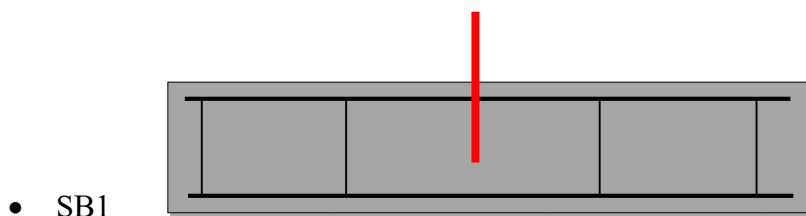
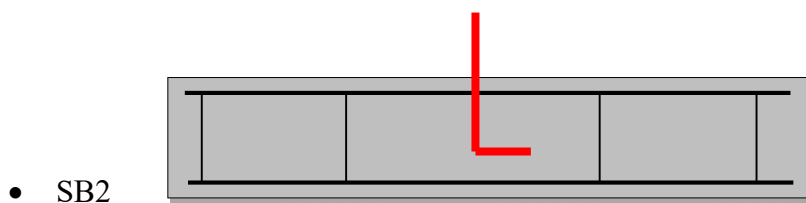
3.3 Mix Design Values:

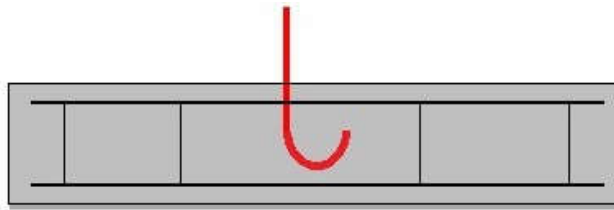
The proportion of M20, M25 and M30 are made for experimental purpose.

Grade	Cement	Fine Aggregate	Coarse Aggregate	Water	Ratio
M20	345 Kg	719.7 Kg	1166 Kg	191.58 Lit	1:2:3.3:0.56
M25	399.125 Kg	456.95 Kg	793.01 Kg	191.58 Lit	1:1.14:1.98:0.48
M30	425.73 Kg	683.3 Kg	1168 Kg	191.58 Lit	1:1.52:2.64:0.45

4. EXPERIMENT AND RESULTS:

To determine the actual bond between steel and concrete, a mix of grades like M20, M25 and M30 are to be made and along with that bars of various diameter like 12mm, 16mm and 20mm are used. The hooks or bends provided to all the bars diameters are abbreviated as SB1, SB2, SB3, SB4 and SB5. Following are provided abbreviations to the hooks.





- SB5

For obtaining the results of the specimen casted a pull out test was performed on Universal Testing Machine (UTM). Following are results obtained for the experiments

4.1 Results obtained for M20 Grade:

M20 GRADE (12mm bar)							
No	Bend/Hook shape	Yield Stress (N/mm ²)	Tensile Strength (N/mm ²)	Load at peak (kN)	Load at Break (kN)	Elongation at Peak (mm)	Elongation at break (mm)
1	SB1	289.403	339.111	89.790	22.032	44.442	52.107
2	SB2	301.493	351.593	98.921	34.195	52.192	58.825
3	SB3	316.925	359.433	104.105	42.210	57.302	66.110
4	SB4	319.129	363.785	100.202	44.356	62.101	65.025
5	SB5	337.554	373.023	112.101	51.301	66.387	71.002

Table: 4.1.1 Result obtained for M20- 12mmØ for different hooks and shapes patterns

M20 GRADE (16mm bar)							
No	Bend/Hook shape	Yield Stress (N/mm ²)	Tensile Strength (N/mm ²)	Load at peak (kN)	Load at Break (kN)	Elongation at Peak (mm)	Elongation at break (mm)
1	SB1	298.025	389.514	102.020	58.031	54.123	67.017
2	SB2	309.452	401.228	109.425	63.119	61.663	73.120
3	SB3	326.340	415.021	115.142	66.631	68.000	78.249
4	SB4	335.019	419.874	124.502	74.825	74.511	82.889
5	SB5	343.009	425.019	134.512	81.021	79.089	83.014

Table: 4.1.2 Result obtained for M20- 16mmØ for different hooks and shapes patterns

M20 GRADE (20mm bar)							
No	Bend/Hook shape	Yield Stress (N/mm ²)	Tensile Strength (N/mm ²)	Load at peak (kN)	Load at Break (kN)	Elongation at Peak (mm)	Elongation at break (mm)
1	SB1	308.198	412.020	121.684	74.258	63.286	61.647
2	SB2	320.425	421.610	133.701	80.086	69.431	67.012
3	SB3	332.808	431.000	141.942	88.079	73.458	73.755
4	SB4	342.999	441.363	153.062	94.704	79.068	81.086
5	SB5	358.012	452.713	164.000	103.052	82.623	89.125

Table: 4.1.3 Result obtained for M20- 20mmØ for different hooks and shapes patterns

4.2 Results obtained for M25 Grade:

M25 GRADE (12mm bar)							
No	Bend/Hook shape	Yield Stress (N/mm ²)	Tensile Strength (N/mm ²)	Load at peak (kN)	Load at Break (kN)	Elongation at Peak (mm)	Elongation at break (mm)
1	SB1	304.512	342.040	98.013	37.120	51.586	61.627
2	SB2	317.729	357.018	116.123	42.314	57.028	67.105
3	SB3	330.121	369.785	124.001	59.041	68.052	77.789
4	SB4	342.082	382.125	135.034	67.621	75.710	85.025
5	SB5	355.501	399.021	144.025	81.124	89.642	98.197

Table: 4.2.1 Result obtained for M25- 12mmØ for different hooks and shapes patterns

M25 GRADE (16mm bar)							
No	Bend/Hook shape	Yield Stress (N/mm ²)	Tensile Strength (N/mm ²)	Load at peak (kN)	Load at Break (kN)	Elongation at Peak (mm)	Elongation at break (mm)
1	SB1	317.729	410.721	105.480	49.420	63.131	72.521
2	SB2	329.100	423.142	119.421	58.175	69.412	81.121
3	SB3	341.842	431.089	127.576	68.954	75.105	91.920
4	SB4	352.014	440.012	134.728	79.951	81.234	99.925

5	SB5	367.852	458.124	143.008	86.546	92.045	113.020
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Table: 4.2.2 Result obtained for M25- 16mmØ for different hooks and shapes patterns

M25 GRADE (20mm bar)							
No	Bend/Hook shape	Yield Stress (N/mm ²)	Tensile Strength (N/mm ²)	Load at peak (kN)	Load at Break (kN)	Elongation at Peak (mm)	Elongation at break (mm)
1	SB1	330.121	431.380	118.120	56.943	72.740	83.120
2	SB2	342.056	440.120	129.489	67.621	83.820	97.975
3	SB3	356.085	458.001	139.873	79.254	91.512	106.125
4	SB4	368.645	471.251	151.120	88.824	103.120	119.941
5	SB5	383.357	783.124	162.024	101.125	114.120	134.746

Table: 4.2.3 Result obtained for M25- 20mmØ for different hooks and shapes patterns

4.3 Results obtained for M30 Grade:

M30 GRADE (12mm bar)							
No	Bend/Hook shape	Yield Stress (N/mm ²)	Tensile Strength (N/mm ²)	Load at peak (kN)	Load at Break (kN)	Elongation at Peak (mm)	Elongation at break (mm)
1	SB1	348.124	453.845	129.245	62.123	71.720	86.825
2	SB2	361.587	464.212	134.201	70.125	81.254	92.123
3	SB3	372.130	473.487	143.246	82.476	92.925	106.125
4	SB4	385.846	482.346	151.246	89.891	105.146	118.142
5	SB5	402.412	493.124	158.124	99.941	119.834	127.521

Table: 4.3.1 Result obtained for M30- 12mmØ for different hooks and shapes patterns

M30 GRADE (16mm bar)							
No	Bend/Hook shape	Yield Stress (N/mm ²)	Tensile Strength (N/mm ²)	Load at peak (kN)	Load at Break (kN)	Elongation at Peak (mm)	Elongation at break (mm)
1	SB1	327.245	452.125	105.127	53.268	69.653	75.162
2	SB2	339.472	468.239	117.124	63.412	79.778	86.542
3	SB3	352.479	476.645	129.249	75.124	89.124	93.134
4	SB4	369.754	489.234	142.412	88.213	96.124	104.120
5	SB5	386.042	501.014	162.124	101.124	109.124	114.102

Table: 4.3.2 Result obtained for M30- 16mmØ for different hooks and shapes patterns

M30 GRADE (20mm bar)							
No	Bend/Hook shape	Yield Stress (N/mm ²)	Tensile Strength (N/mm ²)	Load at peak (kN)	Load at Break (kN)	Elongation at Peak (mm)	Elongation at break (mm)
1	SB1	330.124	476.214	118.124	56.348	79.124	83.825
2	SB2	348.124	482.124	129.465	69.215	88.825	92.912
3	SB3	361.745	499.021	142.124	81.124	98.124	101.248
4	SB4	375.641	511.034	161.246	92.124	113.014	119.142
5	SB5	391.548	528.415	175.124	101.124	119.025	129.246

Table: 4.3.3 Result obtained for M30- 20mmØ for different hooks and shapes patterns

4.4 Graphs of the Results Obtained

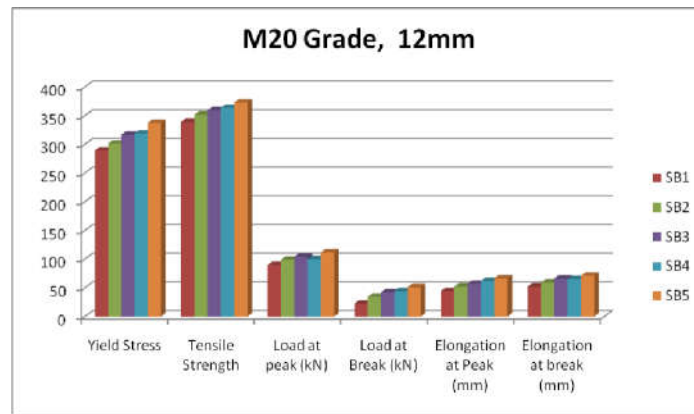


Fig 4.4.1:- Graphical representation of table 4.1.1

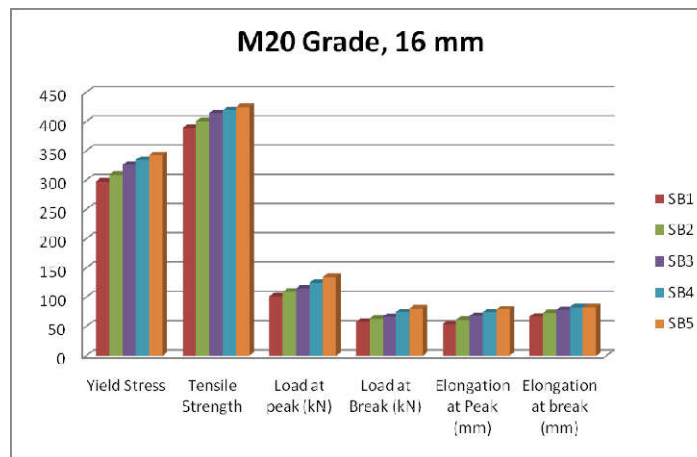


Fig 4.4.1:- Graphical representation of table 4.1.2

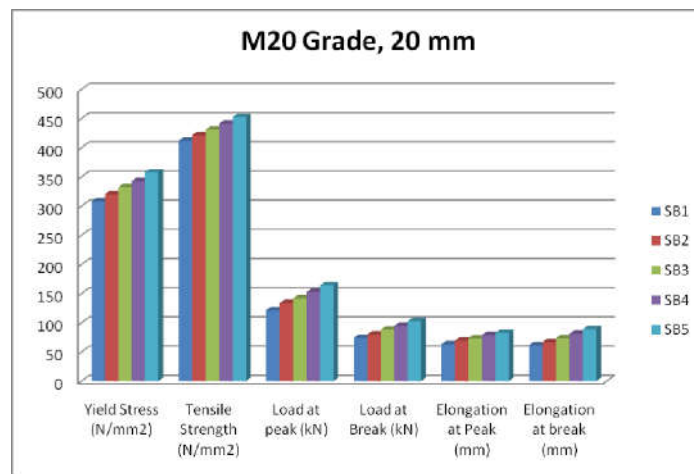


Fig 4.4.1:- Graphical representation of table 4.1.3

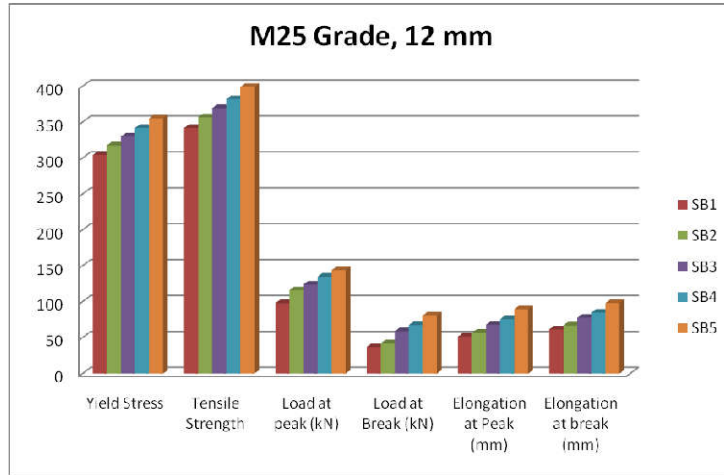


Fig 4.4.1:-Graphical representation of table 4.2.1

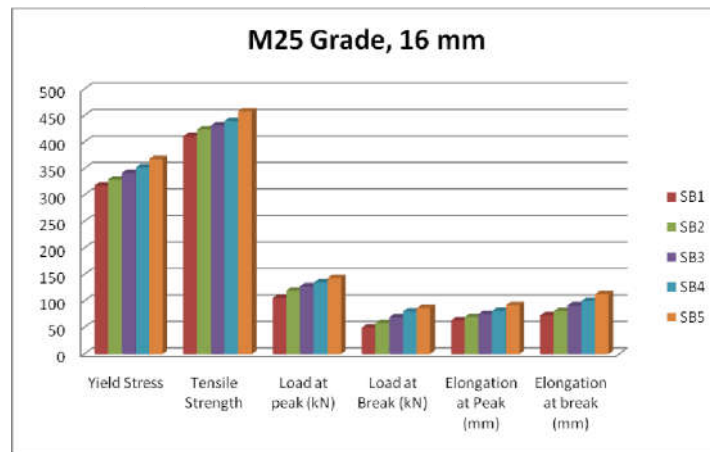


Fig 4.4.1:- Graphical representation of table 4.2.2

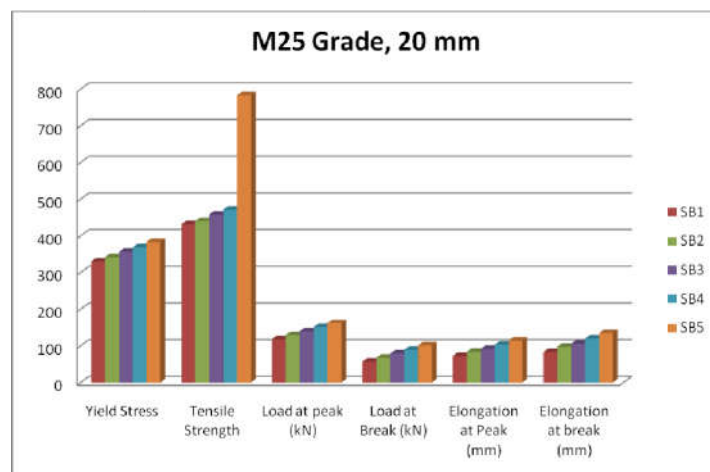


Fig 4.4.1:- Graphical representation of table 4.2.3

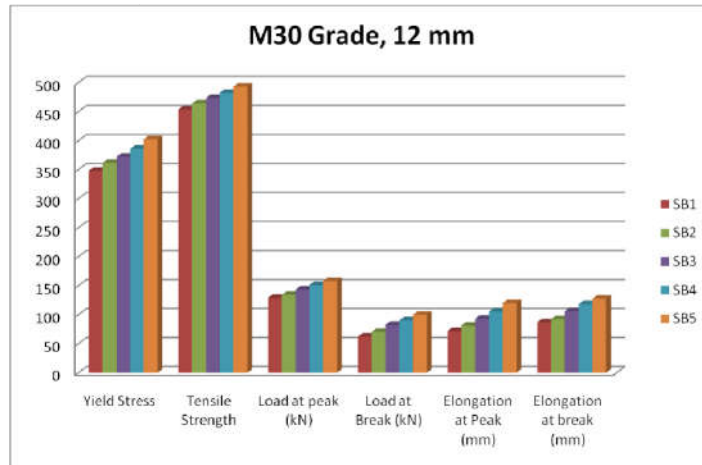


Fig 4.4.1:- Graphical representation of table 4.3.1

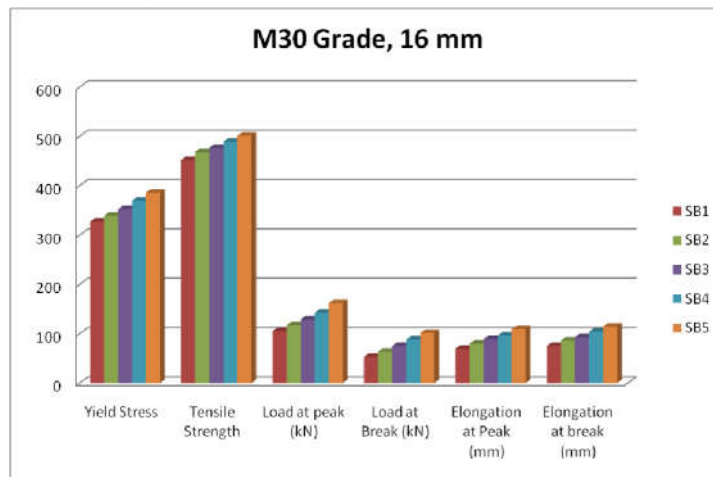


Fig 4.4.1:- Graphical representation of table 4.3.2

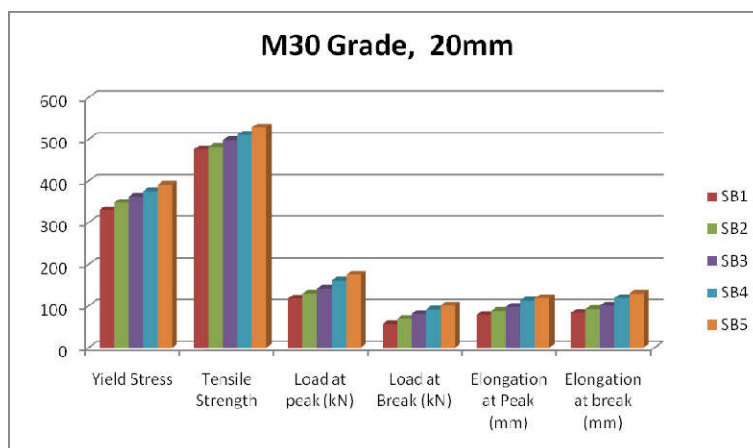


Fig 4.4.1:- Graphical representation of table 4.3.3

5. CONCLUSION

From the experiment conducted in the report it can be concluded that bond strength of the concrete and steel bars depends upon various factors. The bond between steel and concrete seems to be increasing by increase in diameter of bar, change in hook shape and Grade of concrete. The pull in upward direction determines the tension produced in specimen and the point at which it breaks.

Some of the factors which are discussed in the report are

1. GRADE OF THE CONCRETE:-

With increase in the grade of the concrete bond strength between steel and concrete also increases. The grade of concrete plays important role in increasing the bond value between steel and concrete. As the grade value increases the interaction of bond is improved and better results are obtained.

2. DIAMETER OF BAR:

Change in diameter of bar ultimately increases the tensile strength of the bar. The greater the diameter of the bar greater will be bond value between steel and concrete.

3. SHAPE OF HOOKS :

Shape and bends provided as per calculated bending schedule is very important aspect while bending the bar. The various hooks as discussed provides better grip and proven to have higher bond value and can bear higher pull in tension condition.

6. REFERENCES

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