Anchor Forces Under CBFEM And Rigid Base Plate Assumption Methods

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Abstract: Design of Post-installed chemical anchors can be designed by referring European Guidelines. Evaluation of Service Report is done by ETA 16/0143. Design method is as per given in ETAG BOND (EOTA TR 029). Design and analysis of Chemical anchors are carried out by structural engineers. Newly developed Component Based Finite Element Analysis (CBFEM) method is used for determining the Anchor forces for Non Rigid Base plate. Rigid Base-plate assumption and non-rigid baseplate CBFEM methods are used for Anchor Calculation. Differences between results of these two methods are observed. Chemical Anchors are used for the study. Design is done on the Profis Engineering Software.

Index Terms: Bonded fasteners, Profis – design, CBFEM, Rigid baseplate assumption, Structural connections.

1 INTRODUCTION

Buildings and structures are aging and needs proper maintenance and also a repairing work periodically. World's Population is increasing day by day this implies increase in need of shelter. Future expansion of existing structure is more cost efficient than constructing new structures. Chemical anchors are used for design work. Chemical anchors used for design work is of HILTI India Pvt. Ltd. Basically, Anchor bolts are used for Structural and non-structural connections. Anchor Bolts are designed for design actions. Anchor rods transfer different loads such as tension loads, shear loads and combination of two. CBFEM is a method used to find Anchor Calculation. Profis Engineering suite is the software used to compare both Anchor force calculations. This is very easy to use software. Design of Post-Installed chemical anchors is done by the guidelines given in Approvals, Codes and Product Manual. Component based Finite Element Method is a new method used in steel connections. There is no clear definition available when a base plate can be considered rigid. It is not possible when base plate is purely rigid. In CBFEM Method, Joint is divided into components. FE Model is used for investigating of internal forces in each component.

2 OBJECTIVES

- The main objective of this study is to compare the forces of Post- Installed Chemical Anchors calculated by Rigid Base Plate Assumption and Component based Finite Element Method (CBFEM) using Hilti Engineering Software.
- The main objectives for undertaking the present study are as follows:
  1. To design a problem of Steel-Concrete connection.
  2. To design Steel-Concrete connection by Manual and software method.
  3. To Calculate Anchor forces by CBFEM and Rigid base plate assumption.
  4. To compare designs done by Rigid Baseplate assumptions and CBFEM.

3 METHODOLOGY

The methodology adopted for this study includes analytical work with supplementary software work using software: Hilti Profis_Anchor and Profis Engineering Suite.

SOFTWARE WORK

1. Design of Steel-Concrete Connection by Rigid Base Plate Assumption using Hilti Profis_Anchor.
2. Design of Steel-Concrete Connection by CBFEM using Profis Engineering Suite.

4 DESIGN PROBLEM

Design a structural Connection for 2 X 2 post – installed adhesive anchor group subjected to tension, moment and shear. Figure 1 show a 2 X 2 anchor group subjected to a design tension force of 6 kN, moment of 8 kNm and a design shear force of 15 kN. Calculate design resistance in tension and shear for the case. Check utilization %. Design by ETAG BOND – SOFA Method.

5 DATA ADOPTED AND SPECIFICATIONS

- Concrete Grade: C 25.
- Condition: Cracked.
- Reinforcement spacing: 150mm
- Anchor Bolt Details: HILTI HIT RE 500 V3 with HIT-V (5.8) M16
- Bolt size = M16
- Nominal diameter of drill bit [d_0 (mm)]= 18
- **Effective embedment depth** [h_{ef} (mm)]**:** =15
- Minimum thickness of concrete member [h_{min} (mm)

- Minimum spacing [S_{min} (mm)] =120
- Minimum edge distance [c_{min} (mm)] =140
- Evaluation Service Report: ETA-16/0143

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- Proof: Design Method SOFA design method - After ETAG BOND Testing

Design by SOFA-ETAG BOND Testing Method:

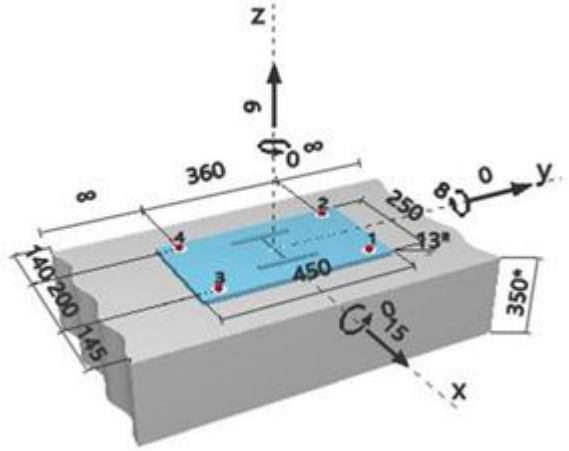

Fig.1. Design problem done with Profis_Anchor

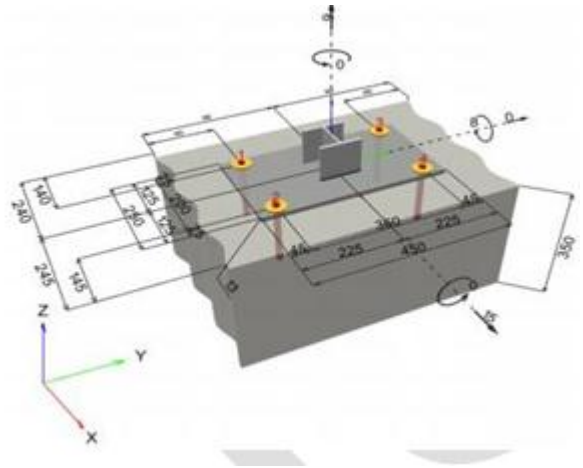

Fig.2. Design problem done with Profis Engineering

6 ANALYSIS OF BASEPLATE

Anchor forces are calculated based on the assumption of a rigid baseplate are:

Table – 1: Anchor reactions [kN]

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	20.439	3.750	3.750	0.000
2	0.000	3.750	3.750	0.000
3	20.439	3.750	3.750	0.000
4	0.000	3.750	3.750	0.000

(+Tension, -Compression)
Maximum concrete compressive strain: 0.13 [‰] Maximum concrete compressive stress: 4.03 [N/mm^2]
Resulting tension force in (x/y) = (-100/0) = 40.877 [kN]
Resulting compression force in (x/y) = (112/0) = 34.877 [kN]

Anchor forces are calculated based on the CBFEM Method are:

Table – 2: Anchor reactions [kN]

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	39.578	3.827	3.784	0.568
2	4.015	3.719	3.716	-0.150
3	39.579	3.827	3.784	-0.568
4	4.023	3.719	3.716	0.150

Resulting tension force in (x/y) =(-81.6/0.0) = 87.194 [kN]
Resulting compression force in (x/y)=(7.8/0.0) = 97.085 [kN]

7 RESULTS AND DISCUSSIONS

The following are the results obtained after analysis using SOFTWARE.
Design Results of Anchors by HILTI PROFIS_ANCHORS: By Rigid Base-plate assumption,

1. Tension load SOFA

Table-3: Tension load SOFA

	Load [kN]	Capacity [kN]	Utilization [%]	Status
Steel Strength	20.439	83.733	25	OK
Combined pullout-concrete cone failure	40.877	52.540	78	OK
Concrete Breakout Strength	40.877	55.621	74	OK
Splitting failure	N/A	N/A	N/A	N/A

2. Shear load SOFA

Table-4: Shear load SOFA

	Load [kN]	Capacity [kN]	Utilization [%]	Status
Steel Failure	3.750	50.240	8	OK
Pry-out Strength	15.000	138.096	11	OK
Concrete edge failure in direction x+	7.500	28.505	27	OK

3. Combined tension and shear loads SOFA

Table-5: Combined tension and shear loads SOFA

	β_N	β_V	$\propto$	Utilization (%)	Status
steel	0.244	0.075	2.000	7	OK
concrete	0.778	0.263	1.500	83	OK

Design Results of Anchors by HILTI PROFIS Engineering:
By CBFEM,

1. Tension load SOFA

Table-6: Tension load SOFA

	Load [kN]	Capacity [kN]	Utilization [%]	Status
Steel Strength	39.579	52.333	76	OK
Combined pullout-concrete cone failure	87.194	51.179	171	Not OK
Concrete Breakout Strength	87.194	53.481	164	Not OK
Splitting failure	87.194	132.065	67	OK

Baseplate deformation (max)	0.3 mm	3.1 mm

8 CONCLUSION

Anchor forces in the CBFEM analysis are more than rigid baseplate assumption. Anchor calculation by CBFEM method, is more accurate than rigid base plate assumption. Profis Engineering software is the software that allows us to design baseplate approach under advance Anchor force calculation

2. Shear load SOFA

Table-7: Shear load SOFA

	Load [kN]	Capacity [kN]	Utilization [%]	Status
Steel failure	3.827	31.440	13	OK
Pry-out Strength	15.000	138.095	11	OK
Concrete edge failure in direction x+	7.432	28.505	27	OK

3. Combined tension and shear loads SOFA

Table 8 -Combined tension and shear loads SOFA

	β_N	β_V	$\propto$	Utilization (%)	Status
steel	0.756	0.122	2.000	59	OK
concrete	1.704	0.261	1.500	236	Not OK

Comparison of Flexible and rigid baseplate:

Table 9-Flexible and rigid comparison

Anchor tension forces	Equivalent Rigid base plate (CBFEM)	(CBFEM) Base plate
Anchor 1	21.5 kN	39.6 kN
Anchor 2	0 kN	4 kN
Anchor 3	21.5 kN	39.6 kN
Anchor 4	0 kN	4 kN
Base plate plastic Strain (max)	None	0.1 %

Type for non-rigid baseplate CBFEM. It is very easy and fast software. The same example solved for rigid base plate assumption is designed for CBFEM. Example passed in the rigid base plate consideration and fails in CBFEM consideration. This is due to difference in analysis and design factors. CBFEM is easier and new technique for anchor forces calculations. SOFA is refers to a Hilti design method which is based on extensive research done by Hilti. The difference between ETAG and SOFA methods are methods of calculation of shear loads. Use of CBFEM worldwide will be beneficial. As it is appropriate method and based Joint is divided into components. There is no clear definition available when a base plate can be considered rigid. It is not possible when base plate is purely rigid. Hence, CBFEM is the effective way to calculate anchor forces under Non Rigid baseplate behaviour.

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