The 2016 World Congress on
The 2016 Structures Congress (Structures16)
Jeju Island, Korea, August 28-September 1, 2016

Prediction of Tensile Strength for Large Anchors Considering the Size Effect

Kang-Sik Kim[1)], Gyeong-Hee An[2)], and *Jin-Keun Kim[3)]

[1)] *Korea Electric Power Corporation Research Institute, Daejeon 34056, Korea*
[2),3)] *Department of Civil Engineering, KAIST, Daejeon 34141, Korea*

ABSTRACT

An anchorage system is essential for most reinforced concrete structures to connect attachments. Prediction of strength of the anchor is very important issue for safety of the structures. Existing design codes are not applicable for large anchors because they are based on the small size anchors with diameters under 50mm. In this paper, a new prediction model for strength of anchors, especially the tensile strength of anchors, is developed from experimental results with consideration of size effect. New model is proposed by regression analysis of experimental results and it can reasonably predict the tensile strength of both small and large anchors.

1. INTRODUCTION

Anchorage systems in concrete structures resist tensile and shear loading either alone or together. Failure modes under tensile loading are steel failure, pullout failure, concrete cone failure and so on. Among these failure modes, concrete cone failure is exhibited by the majority of mechanical and cast-in-place anchor systems (Eligehausen, Mallee and Silva). Prediction of resistance of anchors by tensile loading, especially failed by concrete cone failure is the main subject of this research.

The existing design codes for reinforced concrete structures such as ACI 318 (ACI Committee 318) or ACI 349 (ACI Committee 349) give the prediction equations for the strength of anchorage systems. However, these prediction equations do not cover the large size anchors with deep embedment depth although large anchors are frequently necessary in reinforced concrete structures such as containment buildings of nuclear power plants.

Large anchors with deep embedment depths have an advantage and a disadvantage to the strength of anchors. Increase in the area of cone due to deep embedment is an advantage because the strength is proportional to the failure surface. Increase in initial crack width due to the large head of the anchor is a disadvantage

[1)] Principal Researcher
[2)] Graduate Student
[3)] Professor mail: kimjinkeun@kaist.ac.kr
Note: Paper to be submitted to "Computers and Concrete, An International Journal" for the purpose of Special Issue.

because of the size effect.

The purpose of this paper is to suggest a model for prediction of the tensile strength of large anchors in non-cracked concrete failed by concrete cone failure. Experiments on large anchors under tensile loading are conducted. Prediction model is suggested based on the regression analysis of the experimental results with consideration of the size effect.

2. EXPERIMENT FOR LARGE ANCHOR

2.1 Materials

Ready-mixed concrete is used for the test and mix proportion of concrete is provided in Table 1.

Table 1 Mix proportion of concrete

w/b (%)	S/a (%)	Unit Weight (kg/m^3)					
		W	C	FA	S	G	Ad.
36.7	41.8	184	426	75	658	959	3.01

Compressive strength of concrete is tested according to the standards, KS F 2404 and KS F 2405, with the cylindrical specimens of $\phi 100 \times 200$ mm. The average compressive strength is 38 MPa.

All anchors were made of ASTM A540 B23 Class 2 steel which is equivalent to ASME SA 549 B23 Class 2 steel used in Korean nuclear power plants. Properties of the anchor bolts are as shown in Table 2.

Table 2 Properties of anchor bolts

Standard	f_y (MPa)	f_u (MPa)	E_s (MPa)
ASTM A540 B23 Class 2	980	1085	2.1×10^5

2.2 Test setup

Test is basically following the standard, ASTM E 488 (ASTM E 488-98). This standard specify the test methods for static, seismic, fatigue, shock, tensile, shear strength of post-installed or cast-in-place anchors in concrete.

Fig. 1 shows the typical static tension test arrangement and it should satisfy the following conditions provided in ASTM E-488.

> “The support for the tension test equipment shall be of sufficient size to prevent failure of the surrounding test member. The loading rod shall be of sufficient diameter to develop the anticipated ultimate strength of the anchorage hardware with an elastic elongation not exceeding 10 % of the anticipated elastic elongation of the anchor, and shall be attached to the anchorage system by a connector that will minimize the direct transfer of bending stress to the anchor. The displacement measuring device(s) shall be positioned to measure the movement of the anchors with respect to points on the test member so that the device is not influenced during the test by deflection or failure of the anchor or test member.”

Note: Paper to be submitted to "Computers and Concrete, An International Journal" for the purpose of Special Issue.