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THE COHERENT CONCEPT OF THE LEVER ARM IN A CROSS-SECTION

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SUMMARY

The coherent concept of the lever arm is presented. The new graphical interpretation of the lever arm Z regarding shear flow together with mathematical justifications are provided. The conclusion is, that the lever arm Z is a crucial parameter which connects shear flow and transverse force and it links diagrams of the normal stress and the shear flow for a cross-section and such a representation is not known at literature. There is an analogy between the lever arm regarding the shear flow and the effective width regarding shear-lag effect for normal stress. The background of historical analysis of the issue is presented.

Keywords: *Lever arm, cross-section, shear.*

1. INTRODUCTION

As for now a lever arm is a well-known concept regarding normal stress and its calculations are complicated for a general case. It is easy to calculate a lever arm at elastic stage for rectangular section and particular formulas can be found for specific cases; for example, for bisymmetric I-section [8]. The approach for a new general kind of composite section, which is proposed in [1], uses lever arm for purposes of design regarding transversal force in composite beam. Graphical interpretation of lever arm Z regarding shear flow (fig. 2.) which is the link between diagrams of normal stress and shear stress is used in [1].

Longitudinal shear stress in beams is well known concept in design codes for steel-concrete composite structures, it is commonly denoted as v_L. Using cross-section presented in fig. 1.a and implementing denotations being used in theory of elasticity one can write $v_L = v_{xz} = v_{zx}$: shear stress multiplied by section thickness results in shear force per unit length (fig. 1.b and 1.c). This is for better understanding and to ensure clarity herein. A shear flow v_{xz} reaches its maximum value at the centroid of the section $[v_{xz}]_{z=0} = v_{xz,max}$. One can notice that using theory of elasticity the lever arm Z is a parameter which connects shear flow v_L and transverse force V_z according to fig. 1.d: it means, that the area of geometrical figure according to fig. 1.c is equal to the area of rectangle according to fig. 1.d and hence the formula (1) applies. A is the area of the section.

$$v_{L,max} = [\tau_{xz} \cdot t]_{z=0} = \frac{\iint_A \tau_{xz}\, \mathrm{d}A}{Z} \tag{1}$$

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