УДК 624. 072. 002.2

CALCULATION OF STEEL CONSTRUCTIONS AFTER SMOOTHING WELDING

Ivanov B.V.
Lugansk National Agrarian University

Introduction. Raising of problem. Choice of bar structures reinforcement scheme is multivariant task. Taking into account modern level of calculation methods and structures design development and also variety of possible schemes and reinforcement methods, development of general approach to optimization problems seems to be task of the future. Solution of optimization problems becomes complicated with the fact that main criteria of reinforcement optimality usually is not material saving or decrease of reinforcement work complex cost, but providing of its most significant manufacturability. Manufacturability means not ease of work execution, but possibility of work execution without production shutdown in minimal terms with aim of decrease of economic losses of enterprise in process of reconstruction [1].

Reinforcement by splicing of section is reasonable for relatively smooth elements. Ensuring of reinforced element firm adherence to structure which is being reinforced with further welding helps to provide further safe performance of composite section and, inversely, welding of element to bent structure can reduce to zero whole reinforcement effect.

Considering all above mentioned it is assumed that we talk about structure reinforcement calculation according to specified scheme with parameters given in advance and with known effects on it. Particularly, presence of residual stress state provided by welding and other methods of local thermal effects (for example welding alignment) will enable increase or decrease of bearing ability and therefore also increase or decrease of structure service life (source).

The aim of work is a theoretical ground of methods of determination of the residual stress state in the steel elements of different section after smoothing by local thermal influences and account of his influence at the calculations of steel columns and other compressed elements of constructions on stability.

Basic part. Special features of calculation of reinforced bar systems are in the first place connected with disturbance of “natural” character of their deformation, especially at reinforcement under load. In connection with this, main attention in what follows will be paid to problems of definition of deflected mode (DM) of reinforced systems in process of reinforcement and further work [1].

In spite of simplification and idealisation of design schemes, problems of reinforced structures calculations remain difficult and in majority of cases can be realized only with help of computer. One of special features of such calculations is need for modeling of reinforcement technology in some cases because it significantly influences on reinforced systems work. Numerical calculations help to receive solutions for particular tasks only by given parameters of system, its initial and limit conditions and particular technology of work production. In this point numerical modeling is like full-scale experiment but with advantage of differential evaluation of influence of one or another factor (not group of factors) on work of reinforced structure and its elements.

Special attention should be paid to presence of residual stress state (RSS). Presence of welding joints and similar thermal effects causes occurrence of residual stresses (RS) in metal structure elements which influence on stability of separate elements as well as on bearing ability and deformability of structures in general. RS influence on stability of compression members is ambiguous. RS of tension on edges increase stability and stresses of compression decrease it. Degree of this influence depends on distribution of RS on section and on rigidness of the latter.

Existing design methods (in the first place ДБН В.2.6-163:2010 [2] and ДБН В.2.3-14:2006 [3] do not take into account possibility of increase or decrease of compression members bearing ability after overlaying of welding joints on belts edges.

Theoretical research of RSS in welding structures, history of their development and degree of influence on bearing ability of welding structures are considered in detail in works [4, 5, 6, 7, 8 et al.].

Methodologies of determination DM of compression reinforced members considering presence of RSS and its influences on stability are expounded in works [1, 4, 5, 6, 8, 9, 10 et al.].

Occurrence of residual bending after unloading is possible if element material passed into plastic state. Alignment is possible by overlaying of idle rolls on edges from side of convex facet (fig. 1). Zones of residual tension stresses (RTS) can be presented as external forces, values of which change in process of further loading (schemes of overlaying welding of rolls and distribution of RS after overlaying welding for some forms of sections are given on fig. 2).

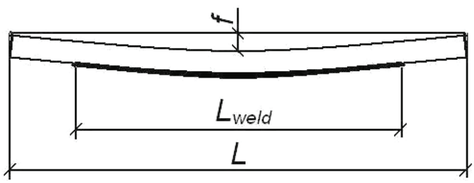

Fig.1. Scheme of overlaying welding of idle rolls in process of alignment of element by welding

Form of deflection curve after overlaying welding can be described by expression of method of initial parameters which were received on the basis of approximation of deflection curve expression by cubic spline ([6, 9] et al.). For this purpose length of element L is divided into n zones and in each *i*-th point of division is defined curvature κ_i. Values of predicted curves y_i and turning angles φ_i are defined by formulas:

$$y_i = y_1 + \varphi_1 \cdot L \cdot \frac{i-1}{n} + \frac{L^2}{6 \cdot n^2} \cdot [(3 \cdot i - 4) \cdot \kappa_1 + \\ + 6 \cdot \sum_{j=2}^{i-1} (i-j) \cdot \kappa_j + \kappa_i] + q_d \cdot (\delta_1 - \delta_i) \quad ; \tag{1}$$

$$\varphi_i = \varphi_1 + \frac{L}{2 \cdot n} \cdot (\kappa_1 + 2 \cdot \sum_{j=2}^{i-1} \kappa_j + \kappa_i). \tag{2}$$

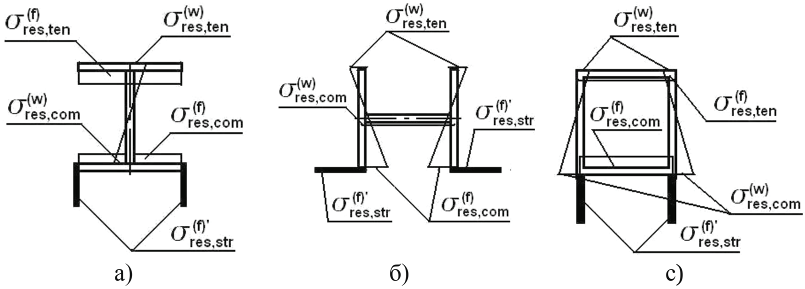

Fig. 2. Schemes of overlaying welding of idle rolls and distribution of RS for different forms of sections: a) alignment of element of double tee section when bending in major rigidity plane occurs; b) alignment of element of double tee section when bending in smaller rigidity plane occurs; c) alignment of element of box section

In general case is considered overlaying welding of idle rolls on length parts of aligned element. Curvature of section can be defined by formula (fig. 2):

$$\kappa_i = \frac{\sigma^{(f)}_{res,com} - \sigma^{(f)}_{res,ten}}{E \cdot h}, \tag{3}$$

where h – distance between section points where values of RS equals zero $\sigma^{(f)}_{res,com}$, $\sigma^{(f)}_{res,ten}$.

Values of RS in section can be defined by known methods, for example [6], considering asymmetry of overlaying welding. Length of overlaying welding zone L_{weld}, parameters of idle roll and other technological parameters of process are established by trial-and-error method, gradually changing them for receiving predicted curve, value of which should be equal to residual curve of element after unloading.

Conclusions.

1. Residual curve can occur in compression members of steel structures after unloading in consequence of passing of material into plastic state. It can be possible by overload of element, changing conditions of load application, decrease of lateral section area because of corrosion etc.

2. Calculation method for parameters of steel elements alignment by overlaying welding of idle rolls on convex facets is offered. Predictable alignment will help to exclude residual curve of structure and ensure elements work with smaller eccentricities of load application.

3. Predictable alignment can be used also for bendable elements except compression members with small eccentricities.

THE USED LITERATURE

1. Ребров И.С. Усиление стержневых металлических конструкций: Проектирование и расчет. – Л.: Стройиздат, Ленингр. отделение, 1988. – 288 с.
2. ДБН В.2.6-163:2010. Державні будівельні норми України. Конструкції будівель і споруд. Сталеві конструкції. Норми проектування, виготовлення і монтажу / Мінрегіонбуд України. – К.: Мінрегіонбуд України, 2010. – 202 с.
3. ДБН В.2.3-14:2006. Споруди транспорту. Мости та труби. Правила проектування / Мінбуд України. – К.: Мінбуд України, 2006. – 359 с.
4. Masubuchi K. Analysis of welded structures. Residual stresses, distortion and their consequences. - London: Pergamon Press, 1980. - 642 p.
5. Николаев Г.А. Сварные конструкции. Прочность сварных соединений и деформации конструкций: Учеб. пособие / Г.А.Николаев, С.А.Куркин, В.А. Винокуров. – М.: Изд-во «Высш. школа», 1982. – 272 с.
6. Голоднов А.И. Регулирование остаточных напряжений в сварных двутавровых колоннах и балках. – К.: Вид-во «Сталь», 2008. – 150 с.
7. Szalai J. A new residual stress distribution for hot-rolled I-shaped sections / J. Szalai, F. Papp // Journal of Constructional Steel Research. – Volume 61. – Issue 6. – June 2005. – P. 845–861.
8. Yang K.-C. Structural behavior of centrally loaded steel columns at elevated temperature / K.-C. Yang, R. Hsu // Journal of Constructional Steel Research. – Volume 65. – Issues 10-11. – October-November 2009. – P. 2062–2068.
9. Голоднов К.А. Деформируемость сталежелезобетонных балок при различных нагружениях // Дороги і мости: Зб. наук. праць / ДДНДІ ім. М.П. Шульгіна. – К.: ДДНДІ ім. М.П. Шульгіна, 2007. – Вип. 7. – Том I.– С. 104–110.
10. Геммерлинг А.В. Несущая способность стержневых стальных конструкций. – М.: Госстройиздат, 1958. – 207 с.