ђqqdyeY bE dsdEbY3e d aoabcy Jqqdyqyè

International Scientific-Technical and Production Journal

The Paton WELDING JOURNAL

April 2012 # 4

English translation of the monthly «Avtomaticheskaya Svarka» (Automatic Welding) journal published in Russian since 1948

Founders: *E.O. Paton Electric Welding Institute of the NAS of Ukraine International Association «Welding»*

Publisher: *International Association «Welding»*

Editor-in-Chief B.E.Paton

Editorial board:

Yu.S.Borisov, V.F.Khorunov, A.Ya.Ishchenko, I.V.Krivtsun, B.V.Khitrovskaya, L.M.Lobanov, V.I.Kyrian, A.A.Mazur, S.I.Kuchuk-Yatsenko, Yu.N.Lankin, I.K.Pokhodnya, V.N.Lipodaev, V.D.Poznyakov, V.I.Makhnenko, K.A.Yushchenko, O.K.Nazarenko, A.T.Zelnichenko, I.A.Ryabtsev

International editorial council:

N.P.Alyoshin (Russia)
U.Diltey (Germany)
Guan Qiao (China)
D. von Hofe (Germany)
V.I.Lysak (Russia)
N.I.Nikiforov (Russia)
B.E.Paton (Ukraine)
Ya.Pilarczyk (Poland)
G.A.Turichin (Russia)
Zhang Yanmin (China)
A.S.Zubchenko (Russia)

Promotion group:
V.N.Lipodaev, V.I.Lokteva
A.T.Zelnichenko (exec. director)
Translators:
A.A.Fomin, O.S.Kurochko, I.N.Kutianova, T.K.Vasilenko
Editor:
N.A.Dmitrieva
Electron galley:
D.I.Sereda, T.Yu.Snegiryova

Address:
E.O. Paton Electric Welding Institute,
International Association «Welding»,
11, Bozhenko str., 03680, Kyiv, Ukraine
Tel.: (38044) 200 82 77
Fax: (38044) 200 81 45
E-mail: journal@paton.kiev.ua
http://www.nas.gov.ua/pwj
URL: www.rucont.ru

State Registration Certificate
KV 4790 of 09.01.2001

Subscriptions:
$324, 12 issues per year, postage and packaging included.
Back issues available.

All rights reserved.
This publication and each of the articles contained herein are protected by copyright.
Permission to reproduce material contained in this journal must be obtained in writing from the Publisher.
Copies of individual articles may be obtained from the Publisher.

CONTENTS

© PWI, International Association «Welding», 2012

ђqqdyeY bE dsdEbY3e d aoabcy Jqqdyqyè

ђqqdyeҮ bЕ dәdЕbҮзe d εɑɑbɔҿ ɈqqdҮqүè

CALCULATION OF LOCAL STRESSES IN WELDED JOINT ZONES OF LARGE-SIZED SPACE STRUCTURES

V.I. KYRIAN, V.I. DVORETSKY and **M.G. MALGIN**
E.O. Paton Electric Welding Institute, NASU, Kiev, Ukraine

An approach to calculation of local stresses in zones of welded joints on structures has been developed. The approach is based on introducing absolutely rigid bodies (ARB) in the form of plane sections into the calculation model. According to plane section hypothesis, ARB provides an adequate transfer of external force effects from one fragment model to another, and permits local distribution of stresses in the zones of the welded joints to be investigated, taking into account the 3D work of the entire structure, thus providing a qualitatively new tool to allow for service loading of elements in evaluation of fatigue life.

Keywords: *large-sized space structures, welded joints, local stresses, finite-element method, finite-element model, absolutely rigid body, calculation*

At determination of the level and repeatability of stresses in welded connections it is highly important to take into account the 3D work of the structure. The main method of 3D analysis of the stress-strain state (SSS) of structural connection and elements is the finite-element method (FEM) which allows approximating any deformed body by a model, consisting of a certain type of finite elements (FE). In mathematical terms calculation is reduced to solving a system of equations of equilibrium, consistency of deformations and physical equations.

At calculation evaluation of welded connection SSS it is necessary to adequately reflect the nature of element interaction in structural stress raiser zones with welded joint geometry. Therefore, it is necessary to approximate the entire structure by 3D FE. It is extremely difficult to perform calculations with such a detailed approximation of all the components and elements. Such calculations require application of high-power computers and are performed in exceptional cases. In common engineering practice calculation of local stresses in welded connections of metal structures of industrial buildings and engineering constructions is related to their separation into individual fragments and stage-by-stage analysis of SSS [1]. The welded structure is first considered as a rod model with specified loads and fastening conditions. Then a fragment with the studied welded connection is separated from the rod model of the entire structure and it is represented as shell FE. After calculation of a fragment from shell FE, the welded connection is separated from it, and is represented by 3D FE. Calculation of the latter gives volume distribution of SSS of each structural element present in it. In such cases, basic and quite difficult to implement is the need to establish at transition from one calculation model of a fragment to another one (with a more complex approximation), the boundary conditions in the form of nodal ties and external force impacts derived in calculation of previous fragment SSS. The complexity is increased in the case of structure operation under alternating loading, leading to a change of the nature of interaction of structural elements of welded connections. In order to adequately represent the influence of external alternating impacts on SSS in the analyzed points of welded connection at different loading schematics, it is necessary to develop new boundary conditions for each calculation model of a fragment. This makes it more difficult to perform structure design, and analysis of the level and nature of stress variation in individual elements of welded connection at the same initial conditions (specifying the design characteristics, design loads and their comparison criteria).

At the same time, in calculations of building structures, in particular, concrete, such an FE as an absolutely rigid body (ARB) is used, which allows creating a rigid constraint between models of fragments, consisting of various FE types [2, 3]. It is used for transfer of information on SSS from one part of structure model to another one. Used as ARB is one of the structural (connecting) elements, as a result of which the entire structure is considered as one calculation model. The idea of ARB application in the form of structural elements is quite good and well-proven at rather simple forms of transition: combining the model of a column of industrial buildings with the model of covering plate from plate FE; combining rod models of ribs of bridge structure beams with the roadway slab from plate FE, etc. At evaluation of welded connection SSS, however, it is difficult to apply ARB in the form of a structural element, as the transition itself (welded connection) should be analyzed.

As deformation of welded structure stressed elements quite satisfactorily obeys the plane-section hypothesis, at each transition from one calculation model of a fragment to another one, it is the most rational to introduce ARB not in the form of a structural element, but as plane ARB — section of structural element of the next model. If certain conditions of interaction of ARB in the form of a plane section with fragment models are followed, it is believed to be possible to perform, using FEM, calculations of local stresses in welded connections of structures of any degree of complexity, adequately transferring hereditary information about SSS from one calculation model to another one, allowing for the loading fea-

© V.I. KYRIAN, V.I. DVORETSKY and M.G. MALGIN, 2012

ђqqdyeҮ bЕ dәdЕbҮзe d εɑɑbɔҿ ɈqqdҮqүè