

THE DEVELOPMENT OF THE REINFORCED- CONCRETE STRUCTURAL MODEL ON IFC SPECIFICATION

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ABSTRACT

We are members of the structure subcommittee of the IAI Japan. Since 1997, we have worked towards a proposal to add reinforced-concrete structure and building foundation information to the IFC building model specifications. This project is called "ST-2". The specification proposal had been carried out in parallel with the international contents adjustment and harmonization with the whole IFC. The final model specification was internationally released in July 2004 in the last revision of IFC2x2 (the present name is IFC 2x3).

In this paper, we will discuss the progress of this reinforced-concrete model decision work, the contents of the proposal, the circumstances of adjustment work, and the contents of the final model, along with the activities for promotion in future.

KEY WORDS

Standardization of building information, IFC, IAI, ST-2, Reinforced-concrete structural model

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1. INTRODUCTION

The authors are members of the structure subcommittee, which works under the "IAI (International Alliance for Interoperability) Japan". Since the activity began in 1997, this subcommittee has worked mainly for the specification proposal to add reinforced-concrete-structural information to the IFC building model specifications. IFC is a global standard in the field of building information modeling. This project is called "ST-2". We presented an interim report about our activity at the ninth ICCCBE in 2002. (reference 1)

After the report, we published a proposal for the specification, set about the implementation of the model in parallel with the international contents adjustment. In August 2004, the final specification was internationally released as part of the final revision of IFC2x2 (the present name is IFC2x3).

In this paper we will briefly review the last report, also describe the contents of the proposal and the development process. In succession, we will report the final specification and how we had harmonized it with the international requirement. In addition we will report what we learned through the participation in the international standard decision working and the overview towards the future.

2. THE OVERVIEW OF IAI, IFC

IAI is the international consortium that was set up in 1995. It is composed of twelve chapters (23 countries) and the membership includes up to about 500 companies. IAI is promoting its activities in the whole world. The purposes of the activities are:

- to define the building model specifications that enable information sharing throughout the life-cycle of a project: planning, designing, building, and operating;
- to promote the interoperability of building information among various professions by building public relations.

IAI Japanese chapter was launched in 1996, institutionalized in 2004 and became "IAI Japan". Sixty-one companies and eighteen research institutes participate in IAI Japan at present. The 61 companies include design firms, construction companies, software development companies, and so on.

IAI proposes the building model specifications called IFC(Industry Foundation Classes). The latest version of IFC is IFC2x3. The core of IFC is the information model expressed by the object-oriented view. IFC is composed of information of the building, the project, and the industry. IFC mainly includes information about:

- building elements;
- shape and size of members;
- location of each member;
- material and physical attribute of members;
- space, storey, room, zone;

- project, organization, etc.

By utilizing IFC we can actualize building information sharing and interoperability among various applications, not only among CAD systems. In the center of IFC, there is a core model that is commonly utilized in many fields of professions. Domain models such as architectural or structural and so on are settled on the core model. (See Figure 1)

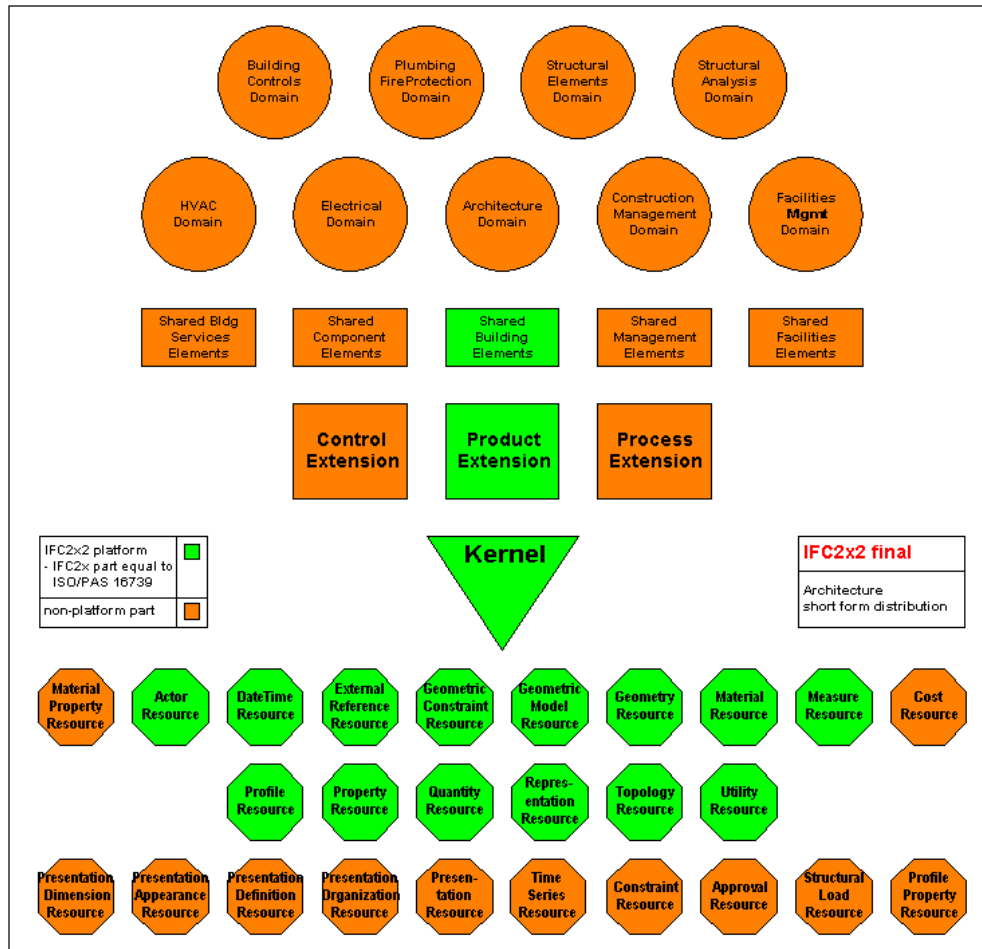


Figure 1: The whole IFC2x3 composition

3. THE OVERVIEW OF THE ST-2 MODEL

When we started working on the proposal, we investigated the whole processes of the structural design. First of all we divided the whole processes into 5 steps: the structural scheme, the structure design scheme, the structure execution design, the production design, and the supervision. After that we investigated the precise data of each step, and selected the second and the third steps as the scope of our proposal. (See Figure 2)

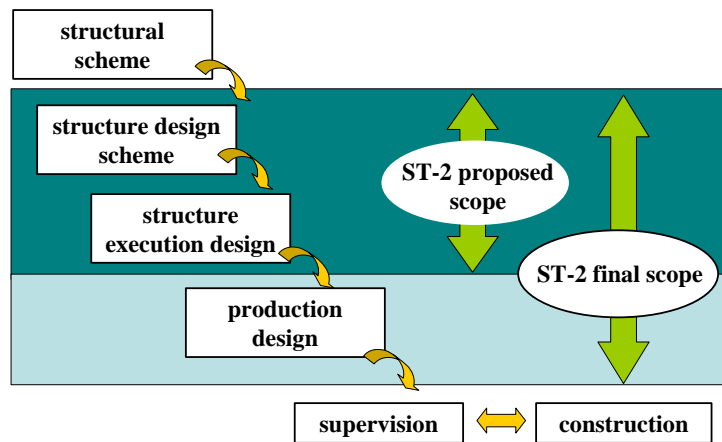


Figure 2: The scope of ST-2 about processes

About the classification of the whole structure, the scope of ST-2 is shown in figure 3. The whole structure field is divided into several projects. ST-2 project is responsible to the modeling of in-situ reinforced concrete structure, ST-3 to pre-cast reinforced concrete structure, ST-1 and 4 to steel structure and analysis. These four projects are already finished and the specifications were released in IFC2x2.

At present three projects are in progress in the structure field. ST-5 for timber structure, ST-6 for harmonization with CIS/2, ST-7 for extended analysis model.

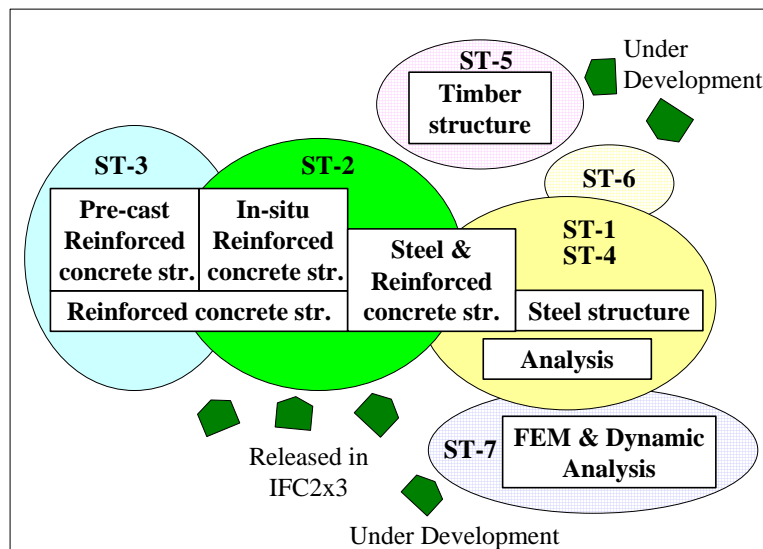


Figure 3: The scopes of the structure projects by the classification

The characteristics of ST-2 model are as follows:

- The structural body is expressed as a wire frame model and the members are connected to the point of intersection of axes which mean the rows of columns and floors.

- The ST-2 model adds structural information to the whole IFC model without largely changing existing model.
- The information of reinforcing bars is described with the diameter and number of bars as the profile of the member section. (See Figure 4)

In other words the structural model shares objects such as columns and beams, which are defined in the architectural model. Also the structural model adds structural effective size and reinforcement bars' information to these shared objects. However, we proposed the new objects of building foundation, which the existing model had not defined.

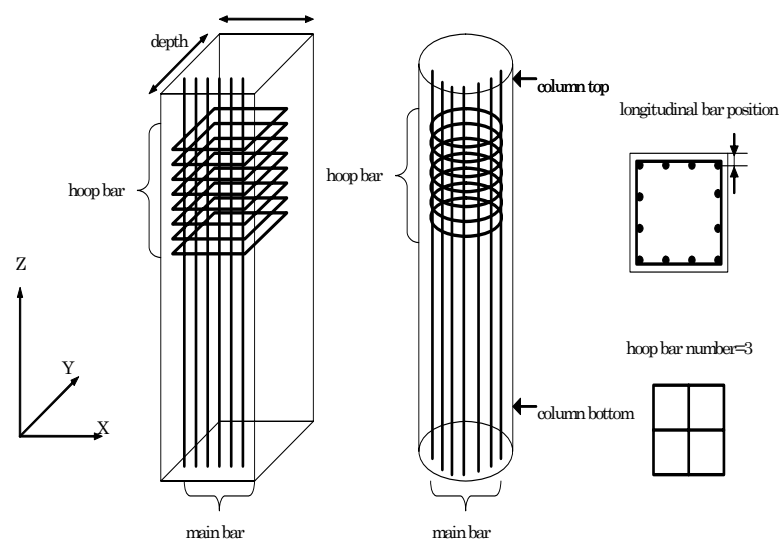


Figure 4: The illustration of the column reinforcing bars in the ST-2 model

4. THE PROCESS OF THE DEVELOPMENT

IFC domain model development is carried out generally through three stages: the requirements definition, the pre-modeling, and the integration. In the pre-modeling, the requirements are written down in the modeling language, Express. In case of ST-2, the expert of Australasian chapter offered to implement the pre-model voluntarily. The integration means the harmonization with the whole IFC. For ST-2, IAI Japan requested this work to the Finnish expert.

In 1997 we started the development of the ST-2 model requirements and spent 7 years until it was finally released in 2004 as IFC2x3. One reason was that we had to repeat the adjustment with the whole model, which was growing up all the time. The arrangements were necessary not only for technology but also for management, for example about the expense for the model integrating work. However in the aspect of the structural technology we could steadily make arrangements in Japan and also with the foreign countries. The process of the development is mentioned below.

- 1997: We decided to propose reinforced concrete and foundation structural model (ST-2) as a domain model of IFC, and started to work. We submitted the first draft in the end of the year.
- 1998-2000: We received domestic and international reviews to our proposal.
- 1999: The draft 4 was released.
- 2000: IAI published IFC2x version as a new platform.
- 2000-2002: The proposal was modified. It was extended for the internationalization and adjusted to the new format for description.
- 2001-2003: The requirements were implemented in the two stages, the pre-modeling and the integration.
- 2003: IFC2x2, which includes four structural domain models, was released. We checked the text and requested some refinements.
- 2004: The confirmed ST-2 model was published as a part of IFC2x3, the latest version of IFC.

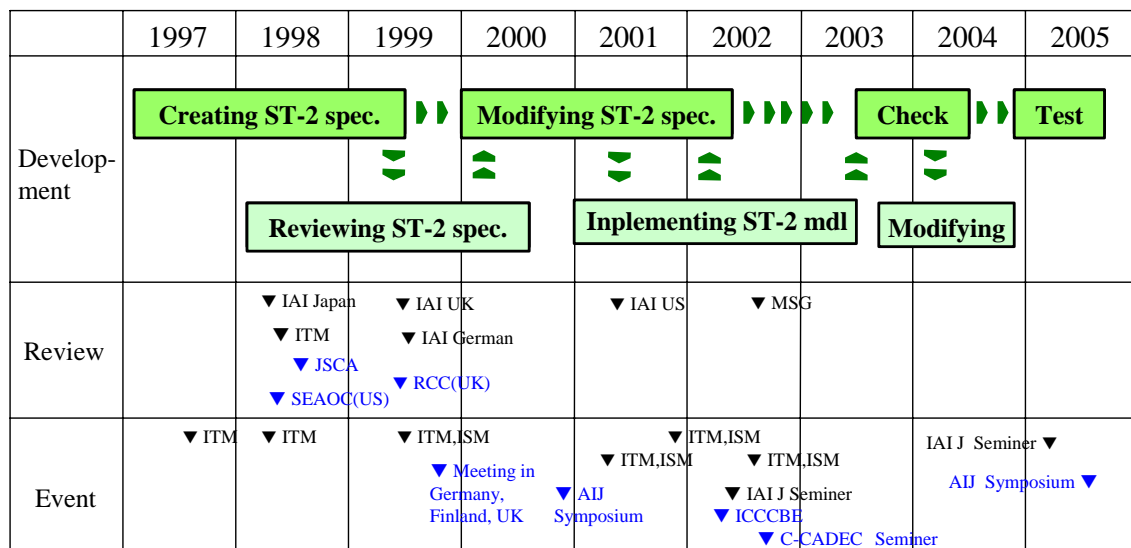


Figure 5: The process of the development

5. THE SUBJECTS ADJUSTED FOR THE INTERNATIONALIZATION

In each stage of the development procedure such as proposing, modeling, and inspection, we received various comments and suggestions, which cover from the definition of the architectural terms to the modeling conception. Corresponding to these remarks we had to adjust the proposed specifications.

The main subjects of the adjustment are as follows:

Specifications of the factory pre-cast concrete structure;

Many people expected ST-2 to include the specifications of the factory pre-cast concrete. However we restricted the scope of our proposal to the in-situ concrete reflecting the Japanese construction circumstances. On the factory pre-cast concrete, therefore, the IAI Nordic chapter initiated a new project as ST-3 in 2000 and it was released in IFC2x2 at the same time with ST-2.

The position description of the building members;

In ST-2 we proposed to describe the location of the building members connecting with the building axes. And this idea was introduced in IFC2x released in 2000. In other words, locations of all the architectural objects can be described in two ways: by the coordinates in the space and by the relationship with the building axes.

The expression of reinforcing bars' detailed shape;

In the stage of the requirements proposal we expressed the reinforcing bar information as the specifications of the member profiles described by the number and the diameter of the bars. That time we didn't describe the length and the shapes of discrete bars. Meanwhile the Australasian cooperator proposed to extend the model so that we could enable the model to express detailed re-bar shape. So we adopted the idea and extended the model. (See Figure 6)


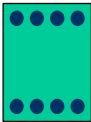
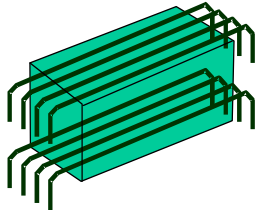
process	Structural Design Scheme	Structural Exceecution Design	Production Design
image			
parameter	Sum of cross section area of rebars	Number and Diameter of rebars	Shape and length of discrete rebars
notes		expression in the proposed ST-2	added expression in the final ST-2

Figure 6: The difference of rebar's expression by process

At the stage of pre-modeling, we also adopted the information of new materials, the meshes and the tendon after the suggestion by the cooperator.

In the first edition of the integrated model, all sorts of reinforcing bars were expressed in the actual number and the diameter. However we Japanese usually express the shear bars of columns and beams, and bars of the planar members like slabs and walls by the diameter and the interval (pitch). So we added in the IFC 2x3 various pitch descriptions in the form of property sets.

The classification by the use of the reinforcing bars

We proposed the attribute list that precisely classified reinforcing bars in Japanese way. For example, in case of the reinforcing bars of the beam: the main-reinforcement>the upper/lower end bars>the first/second row bars; shear bars; spacing bars; were requested.

However in the integrated model the reinforcing bars are roughly classified as MAIN, SHEAR, LINK, STUD etc. And for substitution discrete bars can be described in detail. Therefore we think it necessary to set local rules for the application in Japan.

6. THE OVERVIEW OF THE FINAL MODEL

In IFC2x3 released in July 2004, some classes written below were added to the previous version, as the structural extension.

- the resource of the profile properties: the objects to show the attribute of the shape, reinforcing bars and structural member section profiles etc.
- the structural members: the footing, the pile
- the structural material : the reinforcing bars, the meshes, the tendon, the plate.

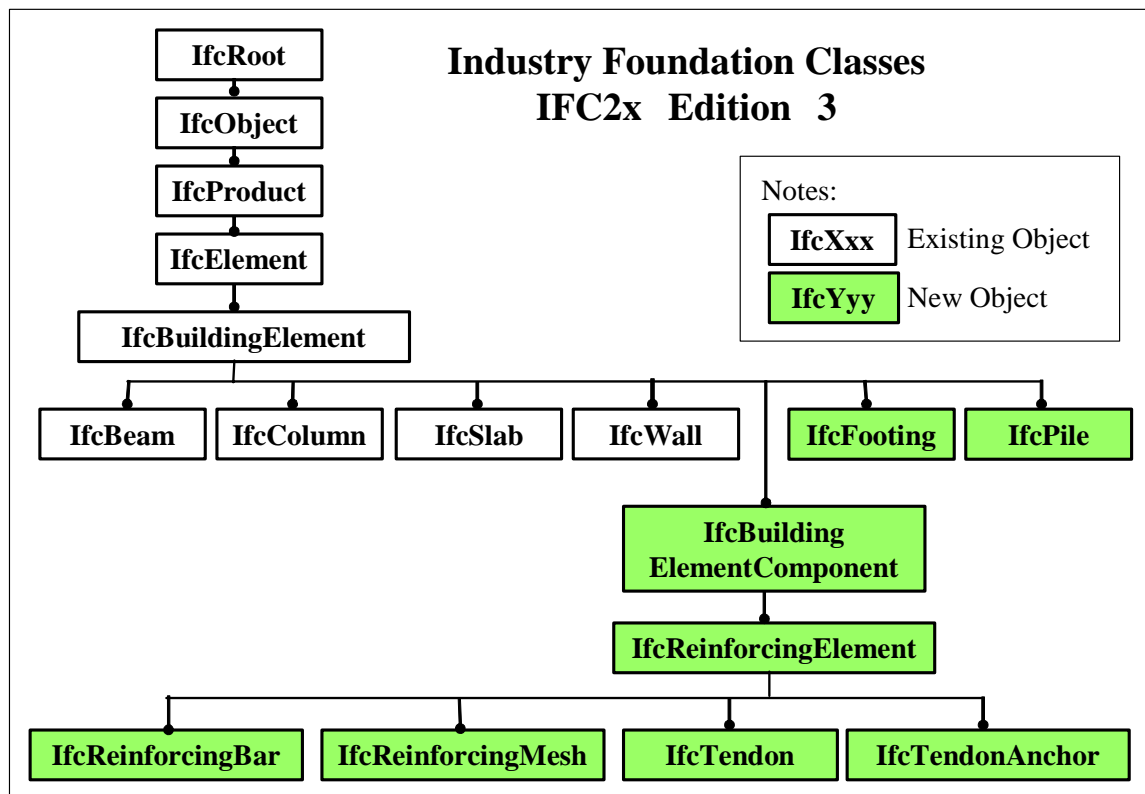


Figure 7: The structural objects added in IFC2x2

The members that compose building foundation were defined newly as the structural objects. Meanwhile the existing objects such as the column, the beam, the wall and the floor, which were already defined before IFC2.0 were expressed as the structural objects by connecting the reinforcing bars information to the existing objects. In addition reinforcing bars information was described with the property set that is a method to describe attributes in IFC model. (See Figure 8)

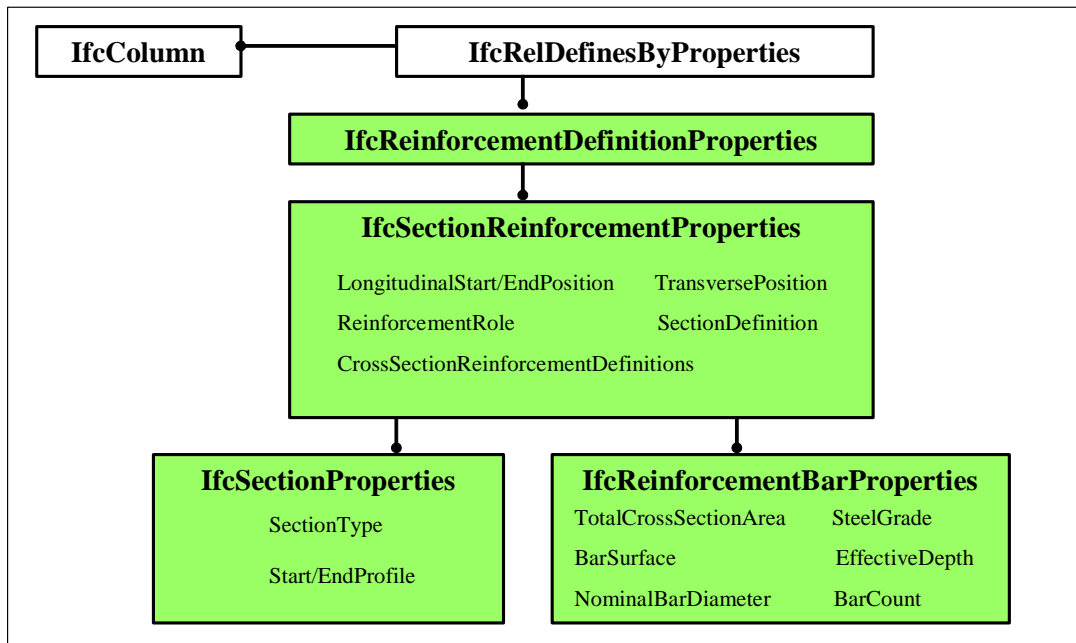


Figure 8: the composition of the reinforcing bars information

7. THE POPULARIZATION SPREAD ACTIVITY

By the last release of IFC2x3 in 2004, the activity for the development of model specification that we had carried out completed with the result as expected. Now we have shifted the focus of our activities to the promotion of the practical use of IFC in the structural field. The subjects of our activities are:

- publishing documents for application users and developers,
- proposing Japanese local rules on the detailed information expression, which are excluded after international adjustment.

When a programmer tries to introduce IFC for a structural application, the heaviest load is to comprehend the enormous IFC and the composition. So in 2004 we started an experimental development to prove the validness of IFC. And we published the outcome as a sample program in IAI Japan. In 2004 we created the program by which one can pick up the structural beams from the whole IFC model and add and edit the information of beam reinforcement and return the edited data to the whole model. In 2005 we extend the program

for other sort of members, column, wall, slab, foundations. In this way every Japanese programmer can easily create the interface with IFC for the structural application.

8. CONCLUSION

The conclusions of this paper are as follows.

- As a part of domain models of the structure field of IFC, the specification proposal of in-situ reinforced concrete structural model was proposed from Japan, and it was accomplished through international adjustment.
- International cooperation was realized over the geographical and linguistic handicap, and it resulted in completion.
- Contents adjustment of a model was performed reflecting the difference in the construction circumstances by the countries. Consequently, it is necessary to propose agreements (local rules) about necessities peculiar to Japan.
- Aiming at spread application of the accomplished model, we'll continue further activities.

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