The ShipWeight concept

An introduction to the philosophy, background and technical solutions behind ShipWeight

SUMMARY

ShipWeight is a computer system for estimating and following up the weight and centre of gravity of a vessel. When the system is utilised in the course of systematically following up weight during the building phase, weights, centres of gravity and other parameters are recorded and structured in such a way as to provide an optimal basis of empirical experience for estimating weights and centres of gravity in subsequent projects.

As well as presenting the methodology and computer technology utilised by ShipWeight, this article discusses a number of problems associated with vessel weight estimation and follow-up.

The “introduction” section of the article goes through the background for the project, while the most central requirements and wishes that were specified before and during the project are discussed in section the “Weight system requirements” section.

The systems and methodology that are behind ShipWeight are discussed in the “ShipWeight solutions” section, while the computing solutions involved are described in the “Experience in use” section.

ShipWeight has only been in use for just over one year, so our experience of using the system is still limited. Such experience as has been gained is discussed in the “Experience in use” section.

INTRODUCTION

Participants

ShipWeight has been developed for the most part at the Dept. of Marine Design at the Norwegian University of Science and Technology (NTNU). Partners in this project have included MARINTEK, the Royal Norwegian Navy, three Norwegian shipyards and three Norwegian ship consultants.

The shipyards were:

- Fosen Mek. Verksteder AS, Rissa
- Kværner Kleven Ulsteinvik AS, Ulsteinvik
- Ulstein Verft AS, Ulsteinvik

The ship consultants were:

- Nordvestconsult AS, Ålesund
- Ulstein International AS, Ulsteinvik
- Vik & Sandvik AS, Fitjar.

The development project has been financed by the Research Council of Norway and the project partners. In spring 1996, BAS Engineering AS was set up; this company is responsible for sales, user support and the further development of ShipWeight.

Background

To a certain extent, ShipWeight displays evidence of having been developed with Norwegian conditions in mind, and for the building of specialized vessels.

Most ships built in Norway are fishing vessels and supply vessels, but a number of Ro-Ro vessels, passenger ships, ferries, seismic ships and bulk vessels and tankers are also built.

The Norwegian shipbuilding industry is also typified by a large number of independent ship consultants who supply designs to a large number of shipyards in Norway and abroad. These consultants often act as the ship-owners’ representatives vis-à-vis the yards.

As well as their ability to build large numbers of special vessels with a high standard of equipment, short design and building times are among the strongest competitive advantages enjoyed by the Norwegian ship-building industry in the international market.

The development of ShipWeight began partly on the basis of the following factors that had been recognised by Norwegian shipyards and ship consultants:

? Weight data available shipyards and consultants are often unstructured and difficult of access, making it difficult to utilise previous experience in estimating weights and centres of gravity in new projects.

? Weight estimation knowhow tends to be limited to a few central persons in design companies and shipyards. As a rule, these persons have developed their own systems, and these systems and the knowhow related to them are not easily available to other persons in the organisation. This means that the company is very likely to lose such knowhow when the person concerned leaves.

? Existing methods and systems are far too static, and pay far too little attention to experience gained from recent newbuildings.

? Shipyards are far too dependent on weight estimates provided by the ship consultant, while at the same time they are not aware of the accuracy and reliability of such estimates. This is in spite of the fact that, in most cases, it is the yards that bear the technical and financial responsibility for the final product.

? Since weight is the main parameter in cost estimation and measurement of progress at most yards, safer estimating methods are needed for better, more predictable project economics.

? It is necessary to quantify the degree of uncertainty involved in estimating weight and centre of gravity in order to be able to identify risks, and well as to allow necessary safety margins in design and economic aspects.

ShipWeight was originally intended to be purely a tool for estimating weight and centre of gravity, and was to help to improve these aspects as much as possible. However, it was gradually realised that it would be necessary to develop a system for following up weight, in order to ensure access to as much as possible of the best available data.

Until now, systematic follow-up of weights while a vessel is being built has not been standard practice at Norwegian shipyards, and traditions and systems for doing so have therefore been extremely limited. This is due to a number of circumstances:

- ? Neither the Norwegian authorities nor the classification societies require continuous control of weight and centre of gravity during the design and building phases.
- ? Shipowners do not demand follow-ups of weight.
- ? Many vessels are non-critical with respect to weight and stability.
- ? Naval architects include wide margins in order to be sure that requirements regarding cargo capacity and stability as set out by contracts and regulations are satisfied.
- ? Bunkering prices are too low, and shipowners are making too good profits, to make it interesting to put more resources into reducing, checking and controlling weight to such an extent that propulsive power and ballast can be reduced.
- ? There is a lack of tradition and insight into the gains that can be made by following up weight, e.g. in the form of:
    - ? greater potential for checking and controlling the development of weight and centre of gravity.
    - ? better input to the processes of production planning and control
    - ? generation of more empirical data on weight and centre of gravity
    - ? generation of more empirical data on costs
    - ? the prospects of reducing margins and increasing profitability.

However, it is worth noting that weight follow-up with the help of ShipWeight has been motivated by the idea of structuring data for use in estimating rather than as a requirement for control of weight and centre of gravity during the building phase.

WEIGHT SYSTEM REQUIREMENTS

The demands made of a weight system by the various actors in the shipbuilding industry are very different:

? shipyard
? designer
? shipowner

The client, i.e. the shipowner, very seldom plays an active role in the design and building phases as far as weight problems are concerned, beyond setting out his requirements regarding the cargo capacity of the vessels. However, weight is utilised at an early stage as an input in concept and cost evaluation. Smaller shipping companies tend to leave this function to their ship consultants.

Flexibility and degree of detail

Shipowners' needs for estimates of weight are usually limited to relatively rough estimates of weight needed as input for concept and cost evaluations. Estimates are usually made on the basis of approximation formulae which in turn are based on statistical data, in addition to hydrostatic curves derived from actual vessels. Estimates are often limited to steel and light-ship weights.

The designer focuses mainly on estimating weight and centre of gravity until the detailed design phase. During the early phase of design, approximation formulae based on statistical data are utilised. New designs are nearly always based on one or more previous projects, and it is normal to scale their estimates up or down. The estimates for the earlier projects are then corrected for real steel and light-ship weights.

The shipyards focus more on following up and checking weights and centres of gravity throughout the whole of the building phase, until launching. Weights and centres of gravity as registered during building are compared with the estimates made by the naval architect during the design phase.

Inputs for weights and centres of gravity may include:

? weights taken from drawings and manufacturers' data
? weighed weights
? estimate formulae based quantifiable and unquantifiable experience.

Hull weight is nearly always derived from weighed sections, while the weight of large items of machinery and equipment comes from the manufacturers. The weights of pipework and electrical systems are obtained from computer models, if these are available.

A complete weight system has be capable of satisfying the requirements of all the above actors. The system must also be capable of adapting to and including as many as possible of the methods and methodologies already in use, in order to make the best possible use of all available knowledge. The degree of detail must be adaptable to the wishes of the users, since these are controlled by internal and external uncertainty requirements.

Uncertainty

A number of circumstances help to determine requirements for accuracy in estimating and following up weights. Access to empirical data and similarities between such data and the new project, for example, will be decisive. A new design will thus require more comprehensive estimates and follow-ups than one of a series of identical vessels whose weight and centre of gravity have turned out not to be critical.

Weight is an important input for cost and progress control during the building phase. In this connection, uncertainty requirements will be governed by project margins and completion deadlines.

Vessels that are critical with regard to trim, stability and movement, such as fishing boats and passenger ships, will require accurate estimates of centre of gravity and detailed weight control during building in order to ensure that the requirements of the authorities and the client are satisfied.

The degree of safety in estimating and following up weight will be controlled to a great extent by the ship-owner’s requirements regarding cargo capacity and speed.

Utilisation of empirical data

It is desirable to be able to make maximum use of available knowledge and information during estimation and follow-up. Such information might consist of:

? light-ship weights and centres of gravity of existing ships, in the shape of displacement tests and heeling trials.

? hull weight and centre of gravity of previously built ships in the shape of section weights

? information regarding the weights of items of equipment and machinery.

? approximate weights of furnishings and equipment relative to area and volume.

? methods and coefficients obtained from the literature.

? light-ship weights obtained from trade magazines and the literature.

Consistent weight breakdowns
For various reasons, it is important to find a consistent method of breaking down a ship's weights:

- ? In order to ensure a one-to-one relationship between estimated weights and weights in the weight follow-up.
- ? To extend the basis for making comparisons from project to project.
- ? To allow data to be exchanged by shipyard and consultant
- ? To improve prospects of establishing standards for estimating and following up weights in terms of both methods and methodology.

In practice, it will be impossible to establish a method of breaking down vessel weights that will be completely identical to all previous practice in this area. The most important objective will therefore be to establish a breakdown method that generally follows previous practice in the shipbuilding industry, and which enables necessary enhancements.

No matter which method is decided on, it ought to be possible to establish relationships between different systems that will make it possible to report weights relative to whatever system is desirable.

SHIPWEIGHT SOLUTIONS

Breakdown system

ShipWeight is based on a hierarchical breakdown of light-ship weight. The breakdown is based on the SFI Group system, but utilises a more comprehensive classification of hull components. The hull is broken down into geographical regions, while for the most part, machinery and equipment are classified functionally. The breakdown has five levels of detail and comprises a total of around 280 items. This makes ShipWeight extremely flexible in terms of details for reporting and estimating.

The most important advantages of this method of classification are that it describes the complete vessel, and that the classification is suitable for estimation purposes.

It is essential to use the same system of classification for estimation and follow-up of weight and centre of gravity, and for all types of vessel. This is to ensure that the basis for comparison of weight follow-ups will be consistent, and to provide the widest possible basis of comparison for estimations.

At the same time, however, the fixed classification system does not prevent weights from being grouped and reported in terms of other systems in parallel.

Methods of estimation

Each individual item in the breakdown structure is linked to a method for weight, VCG and LCG. These methods have been obtained from the literature and from persons who have experience of estimating weights, such as

? Watson,Gilfillan [1]
? Schneekluth [2]
? Harvald,Juncher Jensen [3]
? Skipskonsulent [4]

All the methods employed are known as coefficient methods, in which the weight or centre of gravity is expressed as a relationship between a coefficient and one or more other parameters. Examples of such methods include:

Light-ship weight	:	W	= k ? Lpp ? B ? D ? Cb
Light-ship longitudinal centre of gravity	:	LCG	= k ? Lpp
Weight of machinery	:	W	= k ? $P^{0.67}$
Weight of deck	:	W	= k ? ro ? A ? t

The coefficients are derived from one or more previously built vessels, or are standard coefficients based on experience or an average of several existing vessels.

Estimating uncertainty

The uncertainty of an estimate is expressed as a standard deviation. This may be quantified in either of two ways:

? dispersion of empirical data relative to a regression line

? subjective evaluation of uncertainty.

A subjective evaluation of the standard deviation may take the form of a percentage estimate made on the basis of experience. The following formula has been used in cost estimation, Lichtenberg [5], and provides an estimate of absolute standard deviation:

$$\text{Standard deviation} = \frac{\text{Max. weight - Min. weight}}{5}$$

Uncertainty can also be expressed in terms of a relative (percentage) standard deviation, made on the basis of experience.

Estimation methodology

The main dimensions and power requirements of a vessel are defined at an early stage of the project. At this stage, estimates are only rough, such as of light-ship weight only or of hull, machinery and equipment separately. As design progresses, more and more parameters are settled and it becomes both necessary and possible to estimate at a greater level of detail. This is done by estimating each of the individual items that make up the hull, machinery and equipment.

The comprehensiveness and degree of detail of the estimates will be determined by the following factors:

? Standards of overall uncertainty

? The quantity and quality of empirical weight and centre of gravity data that are available at different levels

? The level of detail of the specifications of the vessel, i.e. how far the design process has proceeded

? Whether requirements regarding the certainty of the centre of gravity estimates necessitate further splitting up of weights.

If an uncertainty is estimated in parallel with weight (and centre of gravity), the absolute uncertainty of each item (i.e. in tons) will determine the degree to which further categorisation and estimates will be required. This is known as successive iteration, and will help to:

? ensure that estimates are always made on those parts of the ship where the absolute uncertainty is greatest
? quantify the overall uncertainty, thus making it easier to know when the estimate is good enough relative to given objectives and requirements
? provide a good picture of those parts of the vessel that have the greatest absolute uncertainty and which thus merit the sharpest focus in the weight follow-up process.

If we assume that a weight item is split up into a number of independent posts, and that the uncertainty of each item is normally distributed, the total uncertainty can be estimated by the following method:

First estimate the light-ship weight as a total weight:

Light ship : W = 2,100 tons S = 10% = 210 tons

Then divide the light ship into three sub-items, and estimate each of them:

Hull	:	W = 1,000 tons	S = 10% = 100 tons
Machinery	:	W = 500 tons	S = 10% = 50 tons
Equipment	:	W = 600 tons	S = 10% = 60 tons

On the basis of these sub-items, the overall uncertainty will be:

Light ship : W = 2,100 tons $S = \sqrt{S_1^2 + S_2^2 + \ldots + S_n^2}$

$S = \sqrt{100^2 + 50^2 + 60^2}$ = 127 tons = 6 %

Generating empirical data
By structuring weight and centre of gravity data on the basis of previously built ships or by weight follow-ups, using the breakdown structure established, a new set of empirical coefficients will be established. These are calculated from the estimation formulae, e.g.

Light-ship coefficient : $$k = \frac{W}{L_{pp} \cdot B \cdot D \cdot C_b}$$

Stiffening coefficient : $$k = \frac{W}{A \cdot p \cdot t}$$

The number of coefficients will be dependent on the degree of detail in the way that weights and centres of gravity are split up.

Structured weight follow-up is therefore of importance not merely in order to allow verification of the development and status of weight and centre of gravity during the building process; it is also the very core of the process of improving the empirical base data.

Software
ShipWeight has been developed in a Windows environment and it runs under Windows 95 and Windows NT. Data are stored in Microsoft Access databases, but MS Access is not required to run ShipWeight.

The system consists of two applications:

? DesignWeight - application for estimating weights and centres of gravity
? AsBuiltWeight - application for weight follow-ups and structuring empirical data,

in addition to the following databases:

? AsBuilt Database - table structure for each individual project’s as-built weights, centres of gravity and parameter values
? Design Database - table structure for each individual project’s estimated weights, centres of gravity and parameter values
? ShipDatabase - empirical database containing weight and centre of gravity data on all vessels that are included in the estimation base
? ShipWeight Database - system database for AsBuiltWeight and DesignWeight.

DesignWeight
DesignWeight is a program application for estimating weights and centres of gravity on the basis of empirical data.

A database is set up for each estimation project.

Estimations are made for the most part by the program calculating the coefficients according to the estimation methods used in the individual weight items, and plotting these in a diagram. The X-axis value is a product of one or more parameters in the relevant approximation formula.

Users themselves select the limitations that should apply to each actual ship to be included in the plot. It is possible to impose limitations on the types of vessel or limiting values for a set of parameters. In practice, the limitations will be controlled by the quantity of empirical data available. A regression line is plotted through the data set and the point at which this cuts the current project's x-value will be the theoretical expected value of the estimate, based on the set of assumptions chosen. The appropriate standard deviation is calculated on the basis of the spread of values of the ships included, relative to the calculated regression line.

It is also possible to click on each individual point on the graph in order to identify the specific vessel represented by this coefficient value, and to bring up a set of accompanying parameter values for the vessel on the screen.

It is also possible to bring up a general arrangement or section of the vessel selected.

On the basis of this information it is possible to make subjective evaluations of whether the vessel whose weight or centre of gravity is being estimated resembles a particular vessel rather than another. On this basis, users can manually modify (12) the selected coefficient (13).

The greater the number of relevant vessels that are included in the empirical database, the more certain will be the estimate. However, it is possible to make estimates on the basis of only a single vessel, but this will amount to no more than a scaling operation.

AsBuiltWeight

The AsBuiltWeight application is used to structure weight and centre of gravity data from existing vessels, or as a tool for direct follow-ups of weights during the building phase.

In the same way as with DesignWeight, a database is set up for each individual project. The user himself decides the level of detail he wishes to include in the individual weight components.

For the hull, for example, we may decide to enter weights at section level, or plates and stiffeners according to the drawings at the lowest level of the breakdown hierarchy.

AsBuiltWeight reports weights in accordance with the breakdown structure that has been set up, but it is also possible to assign codes to each individual component weight, making it possible to report weights and centres of gravity for:

? Sections (101, 102, 103, etc.)
? Areas (main deck, mid-deck, upper deck, etc.)
? Modules (cargo area, superstructure, wheelhouse, etc.)
? Functions (cargo-loading system, machinery, passengers, etc.)
? Disciplines (steel, HVAC, pipework, instruments, electro, etc.)
? Type of material (bulk, equipment)
? Installation codes (installed, not installed)
? Weight status (estimate, drawing, manufacturer’s data, computer model, weighed, etc.)

When weight and centre of gravity are available from displacement tests and heeling trials, and data from the weight follow-up have been verified with respect to these results, the desired information is transferred to the empirical database. This database contains empirical data for all vessels, and it is from this database that DesignWeight retrieves empirical data for use in making weight estimates.

EXPERIENCE IN USE

Structuring empirical data

ShipWeight has been developed primarily in order to enable individual users to optimise their own empirical data. This means that each individual user needs to enter his own data in the database, either by structuring existing vessels or via weight follow-ups of new projects.

Most users of ShipWeight have put a great deal of effort into structuring the weights and centres of gravity of previous projects. These have mostly consisted of hull weights (sections) and the weights of machinery and equipment components. However, structuring weight data from existing vessels has proved to be a highly labour-intensive process, and it is thus highly preferable to carry out this task in the course of an ongoing project.

Weight follow-up using AsBuiltWeight

As mentioned in the introduction, there has never been, and still is not, a widespread practice or tradition of active weight follow-up when ships are being built. This is related to the following factors:

? Available resources and economic conditions
? Requirements of the authorities and contractors
? Understanding of the weight problem, and the possibility to check and control it.

Shipyards that have used ShipWeight, however, have initiated active follow-ups of weights and centres of gravity during the building phase. This follow-up has involved a person being given responsibility for entering and checking weight data and for reporting tendencies and results, while it has been the responsibility of the individual disciplines to obtain the relevant information. This is reported to have worked well, but it requires the person in charge to have multidisciplinary knowhow. The advantages of managing weight follow-ups in this way rather than allowing each discipline to enter its own weights are as follows:

? It limits training in using the system to a small number of persons, which usually results in a higher level of knowledge and efficiency among those who work with the system, and reduces the likelihood of errors being made.
? It reduces the chances of double entry of information.
? It sharpens focus on weight and on the quality of the weight information.
? It increase the likelihood of being able to make an objective and relative assessment of weight information, which leads to better control of the total consumption of resources used on weight.
? It increases the possibility of exchange of experience with system developers.

The disadvantages have been:

- ? It requires a person with multidisciplinary knowhow to ensure a good result of the follow-up.
- ? It increases the amount of work involved in entering information for the person or persons who have responsibility for the system.
- ? In general, it takes longer to enter available weight information into the system.
- ? It increases the likelihood that weights will be forgotten, since the person who has to enter the data does not usually have detailed knowledge of everything that is to be installed.

Experiences of weight follow-up and the use of AsBuiltWeight are mixed, but the positive feedback can be summarised as follows:

- ? The system and the classification structure function well for entering and registering weight and centre of gravity.
- ? It is considerably less demanding of resources to systematise weight information in the course of an active follow-up process, than to do the same work after the project has been completed.
- ? The system provides good, comprehensive empirical data for systems, particularly in the departments of machinery and equipment, which have not previously been available.
- ? It improves our understanding of the parameters that affect weight.
- ? It raises the level of our requirements regarding the quality of weight information supplied by subcontractors.
- ? It increases the incentive to utilise and increase the generation of information on weight and centre of gravity from various CAD/CAM computer models.

The greatest disadvantages of the system so far have been:

- ? There are insufficient possibilities to report weights relative to other systems and classifications.
- ? It is difficult to obtain 100% registered weight relative to actual weight. The system ought to be better able to ensure that everything is included.
- ? The program should offer more possibilities to correct underlying weight vis-à-vis the updated and verified total weight (results of heeling trials).
- ? The methodology involved in the program and the system has been difficult for some people to understand. This is due, among other factors, to:

    - ? limited general understanding of computer techniques among users.
    - ? little knowledge of weight follow-up and little possibility of obtaining training in this field.
    - ? the fact that not all parts of the program are as intuitive and user-friendly as they might have been.

Weight estimation using DesignWeight

Relatively limited experience has been gained in estimating, in comparison with weight follow-up. This is largely due to the short time during which the system has been in use, plus the fact that input from the follow-up process is the basis for the estimation process.

The most interesting aspect of this area is the joint understanding arrived at by shipyards and consultants regarding exchange of weight information. Yards that were originally extremely sceptical and negative to the idea of giving external ship consultants and designers access to detailed weight information from the building phase have realised the value of doing so in the form of obtaining better, more reliable weight estimates from the consultant in the longer term.

Items of positive feedback and experience in the use of DesignWeight are as follows:

? The top-level estimation method appears to be sensible, and there is a strong belief that this will offer good estimates in due course.

? The breakdown structure and division into weight items is sensible, and users with little or no experience of weight estimation find it easy to accept and understand.

? The system offers an effective way of making rapid, rough and ready estimates in the early design phase. Feedback from shipowners is particularly positive in this area.

? The system offers an effective way of observing changes in weights and centres of gravity when existing vessels are being scaled, or when main weight and power parameters are being modified.

? The system forces users to employ a systematic set of procedures in the estimating process.

Objections to the system have been the following:

? It is difficult for experienced users of existing systems and ways of thinking to accept the set of divisions. These people want more freedom with respect to how the vessel should be divided up.

? The system requires a certain number of vessels as a basis of comparison in order for the estimates at detailed level to be sufficiently good. This is particularly the case for the hulls of specialised vessels such as supply ships, in which it is difficult to take all the special cargoes and design solutions into account. This has something to do with the fact that empirical data from hulls are usually obtained from section weights, so that it is the division into sections that governs the way the hull is divided up.

? The system should have had a method of division that could increase the possibility of making more estimates within a given item, e.g. an individual estimate for each individual deck in the item “deck in cargo area”. Due to the hierarchical breakdown, these items currently have to be estimated as a sum.

FUTURE DEVELOPMENTS

AsBuiltWeight

The future development of AsBuiltWeight will be governed first and foremost by the feedback received from users.

We will also attempt to adapt the system to international weight follow-up standards. Some of the systems and methodologies used in the offshore industry will also be incorporated, e.g:

- ? The possibility of attaching more information and codes to each individual weight entered.
- ? A wider range of possibilities and more flexibility in structuring and reporting weights and centres of gravity.
- ? Extending and modifying the breakdown structure to enable AsBuiltWeight to generate an even better basis for weight estimates that it does at present. This applies in particular to the hull. One example would be to identify double bottoms as a separate area, perhaps within the machinery area.
- ? Developing a system which, on the basis of detailed information from existing vessels, could ensure that users remember to enter all weight items. This would ensure that 100% of the weight is reported during the follow-up process.

DesignWeight

As for AsBuiltWeight, the future development of DesignWeight will be influenced by the wishes and demands of users. However, a number of functions that will be incorporated in forthcoming versions of DesignWeight have been specified. These include the following:

- ? Implementation of alternative methods of estimating weights at various levels of detail. These will include both methods found in the literature and others developed by individual users. These methods will primarily be used to verify the values obtained by estimates using DesignWeight, or when the available empirical data are poor.
- ? Development of a library of standard coefficients for each item in ShipWeight’s breakdown structure. These coefficients will indicate a mean value for a given type of vessel and size range, in order to provide material for making estimates when data from actual ships are inadequate.
- ? Integration of methods from artificial intelligence (neural networks), in order to improve our ability to predict how changes in a large number of parameters will affect weights within a given item.

New applications for the ShipWeight methodology

Building costs

Since weight is an extremely important input to the cost estimation process, it is tempting to look at the possibility of developing ShipWeight in the direction of cost estimation. We would use the same breakdown structure and estimation methodology, but the methods would be modified to deal with costs rather than weights.

Resistance and propulsion

We have also discussed the prospect of using the ShipWeight methodology to estimate resistance and propulsion on the basis of empirical data from towing and acceptance trials. Whether or not this would be practical is less certain, and is a matter for the future.

DEFINITIONS

ro	Unit of weight for steel plates
A	Area
B	Beam
Cb	Block coefficient of vessel’s highest full-length deck
Lpp	Length between perpendiculars
P	Power of machinery
Parameter	Variable that describes a quantity, e.g. length, beam, machinery power
Parameter value	Value of a variable, e.g. 100 m, 1000 kW, 12 mm
Standard deviation	A measure of uncertainly, whether relative or absolute. On the basis of a most likely value and a given distribution of uncertainty, we can predict the range within which a value is likely to lie.
t	Plate thickness
Weight estimation	By employing a method based on experience and empirical data, we can say with a certain degree of accuracy how much a construction is likely to weigh when built.
Weight checking	Checking weight at a given point in time by registering the most accurate weight information available at the time.
Weight follow-up	An activity that comprises weight checking and weight control.
Weight control	Predicting and actively influencing weight trends in a construction on the basis of information from weight checking.

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