Department of Agriculture, Food and the Marine
An Roinn Talmhaíochta, Bia agus Mara

Protocol

for

Structural Design of Marine Finfish Farms

(subject to revision from time to time)

April 2016

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1. Introduction

All marine finfish farms shall be subject to full structural design. They shall be designed to at least meet the standard set out in this protocol.

Structural design of a proposed marine finfish farm is considered to be a two stage process – preliminary design and detailed design.

The preliminary design is carried out to the extent that preliminary design loadings and resultant applied forces are established and these are evaluated in the design analysis to produce a provisional outline design for the farm structure.

The preliminary design will indicate position and orientation of the main structural components of the finfish farm, identify principal dimensions of nets, pens and moorings and include sufficient detail to allow production of a set of site specific drawings that illustrate the structure of the proposed farm. These preliminary design drawings will be submitted as part of the licence application and will also be referenced in the licence (if issued). It is important that the drawings are drafted to a professional engineering standard and include all relevant information. Drawing requirements are set out later in this protocol.

The detailed design stage follows later, following issue of a licence and before farm deployment. Following selection of the equipment supplier, the licence holder will be in a position to specify in detail all elements of the structure proposed for deployment at the site. The capacity of each element to withstand the applied design forces shall be evaluated in detail in this second detailed stage of the design.

Detailed design stage also requires confirmation by a Competent Person[1] that the marine finfish farm has been designed with skill, care, diligence and professional conduct reasonably to be expected from a designer with the qualifications and experience suitable for the design work involved. This confirmation shall be submitted to the Department with detailed design documentation before any finfish farm equipment is deployed at the proposed site.

The protocol also outlines procedures for design-associated record keeping and for review of the design during the operational life of a marine finfish farm.

[1] Competent Person in this protocol means a person who is a Chartered Engineer of Engineers Ireland or other Professional Engineer meeting the definition adopted in 1960 by the Conference of Engineering Societies of Western Europe and the United States of America (EUSEC).

2. Design Information to be provided at licence application stage

2.1 Preliminary Design

A preliminary design shall be carried out prior to an application being submitted.

The preliminary design shall consider in sufficient detail the provisions outlined in Sections 4, 5, 6, 7 and 8 of this protocol, to allow the drafting of a set of site specific drawings. It shall also include an initial assessment and sizing of the proposed set of nets, pens and mooring system to withstand the maximum design loads acting on the farm. This preliminary assessment shall be such as to identify the principal structural components of the proposed farm and their principal dimensions.

The principal output from the preliminary design shall include a set of drawings showing the proposed farm as designed following completion of the preliminary structural design and be to such a level of detail so that the later detailed design will not significantly alter the principal dimensions and orientation of the proposed net, pen and mooring system.

2.2 Drawing Requirements (Preliminary Design)

The minimum drawing requirements considered necessary for illustrating the preliminary design are set out in the Appendix to this protocol.

The licence applicant shall include the preliminary design drawings with the application.

If the preliminary design and/or drawings submitted with the application are deemed inadequate or incomplete the application may, in the case of serious deficiencies, be rejected; or, if requested, the applicant shall revisit the preliminary design and provide revised design drawings prior to issue of the application for public consultation.

A set of these drawings and the preliminary design documentation shall be maintained in a design file by the applicant.

If a licence is granted the preliminary design drawings submitted will form an integral part of the licence; and they will be specified as approved drawings in a schedule to the licence.

For illustration purposes a typical drawing for a marine finfish farm (preliminary design stage) is available on the Department's website:
www.agriculture.gov.ie/fisheries/aquacultureforeshoremanagement

3. Detailed Design and Confirmation by Competent Person

3.1 Detailed Design (General)

Where it is decided to issue an aquaculture licence the licence holder may decide to examine a wide range of possible suppliers for equipment supply.

The licence holder must ensure that the marine finfish farm components proposed for deployment meet or exceed the design requirements arrived at in the preliminary design.

The structural adequacy of the proposed farm shall be fully demonstrated in the detailed design process.

The detailed design shall cover Sections 6, 7 and 8 of this protocol in full having regard to Sections 4 and 5. It shall draw on the output of the preliminary design stage and develop it to a fully completed design.

It is a requirement that detailed design must be provided before deployment of any farm components at the site.

Design software (where used) shall be identified by name and release version in the design record.

The maximum structural forces and associated internal stresses acting on each major component of the fish farm system, as derived in the structural design process, shall be clearly tabulated in the design record.

The output of the detailed design analysis shall be a specification and set of drawings of the proposed structure of the farm.

3.2 Detailed Design Statement

A detailed design statement by a Competent Person shall be submitted to the Department for approval following completion of the detailed design and before deployment of any farm components at the site.

The detailed design statement shall:

a) describe in summary form the structural design analysis carried out at detailed design stage;

b) detail the specification of each component of the marine farm, including: type, size, material composition, dimensions, minimum strength/ load capacity; where applicable the manufacturer, proprietary name and model number of a particular product shall also be given;

c) confirm that the detailed design of the net, pen and moorings meets this protocol for structural design;

d) include a proposed programme of measures to be followed to ensure that structural integrity of components and farm as a whole will be maintained within designed parameters when operational;

e) include written confirmation by a Chartered Engineer that the marine finfish farm to be used in the licensed site has been designed with skill, care, diligence and professional conduct reasonably to be expected from a designer with the qualifications and experience suitable for the design work involved. (This is also a condition in the licence template for marine finfish aquaculture).

f) include a set of drawings showing the proposed farm following completion of detailed structural design stage.

3.3 Drawing Requirements (Detailed Design)

The minimum drawing requirements considered necessary for illustrating the detailed design are set out in the Appendix to this protocol.

The drawing set shall include site location plans, layout plans, cross sectional elevation drawings and detailed cross section drawings to the scales recommended in the Appendix to this protocol.

The detailed design drawings should complement the detailed specification information generated in the detailed design stage and listed at 3.2(b) above.

The Detailed Design Statement, including a set of the detailed design drawings, shall be maintained in the design file by the applicant.

4. Design Conditions

The worst case conditions to be designed for are to include storm waves (and currents) from various incident directions which (individually) have a 2% (1/50) probability of being exceeded in any particular year.

Parameters to be determined for structural design purposes shall include the following:

design wind speed:	wind speed at 10 m above sea level with a 50 year return period.
design current velocity:	current velocity at relevant depth[2] with a 50 year return period.
design wave parameters:	significant wave height with a 50 year return period and corresponding peak wave period.

The design wind speed, current velocity, wave height and wave period values shall be determined at the representative point(s) on the proposed marine farm site. It is recommended that these values are accurately derived using an appropriate[3] combination of in-situ measurements and modelling techniques.

The design wind speed, current velocity, wave height and wave period values shall be determined at the representative point(s) for at least 8 equally spaced incident directions (these would typically be the cardinal and ordinal directions - each representing an angular segment of 45 degrees).

The four design values for each of the eight directions shall be tabulated in a single table of design values.

Where incident directions, other than the eight listed, may be expected to give higher values for the design parameters referred to above, these directions shall be included in the assessment. Where it may be reasonable to expect that particular incident direction(s) will produce very low values for certain parameters, the values for such directions may be considered negligible; and the values may be recorded as such in the table of values, without inclusion of supporting detailed calculation. This expectation may be based, for instance, on existence of nearby coastal forms, local bathymetry or in-situ data measurement.

[2] In the collection of in situ current data the variation of current velocity with depth shall be assessed. If current velocity is found to be reasonably uniform over the depth profile at the site the relevant depth for design current may be taken provisionally as MLWS minus 5 metres). If there is significant current velocity variation with depth at the site then current velocity at near surface, anticipated mid-level and anticipated bottom levels of net shall be determined.

[3] For instance it will be important in most cases that the output values from current velocity models will have been calibrated and verified against in situ measurements.

5. Estimated Loadings

Estimated loadings acting on the components of the marine farm shall be derived based on the expected actions on the farm structure of the various worst case winds, waves and currents from the various incident directions of relevance as established in Section 4.

Where appropriate, the wind, wave and current actions shall be applied in combination to the structure(s).

The design analysis will use predicted wave heights and current velocities to derive loads / forces acting on the net, pen and moorings. The design analysis shall be based on the application of recognised mathematical formulae and computer based analysis techniques (where used).

The basis of the design analysis and techniques used shall be clearly summarised in the design record.

The methods used for deriving internal stresses from applied forces for the various structural components of the farm shall also be outlined where appropriate.

6. Net Design

The net system shall be designed to structurally withstand the maximum design loads acting on the net.

Appropriate load factors shall be applied to the estimated loads on the net (established in Section 5) to arrive at the maximum design loads. Appropriate material factors shall be applied to yield strength values in providing for sufficient reserve structural capacity in materials used.

Allowance shall be made for reduction in net twine breaking strength over time and the threshold strength values set to determine net serviceability.

In designing for current induced loadings the designer shall allow for increased current drag due to net fouling. The degree of net fouling allowed for in the design shall be stated.

The design shall provide sufficient clearance between net and sea bed under all tidal and wave conditions.

The net weighting system, for maintaining net shape under hydrodynamic action, shall be designed to be effective at maximum design loads.

The design shall consider the adequacy of net containment for anticipated maximum fish stock levels and shall ensure against excessive net bagging/ fish stock crowding at maximum design loads on the net. The net shall be designed to maintain full containment of stock for the predicted design load conditions.

Provision shall be made in the design for potential interaction with other nets, or structures located in the vicinity of the net.

In addition to designing for hydrodynamic loadings, the designer shall ensure that the net is fully designed for operational loadings including those operations that could cause significant net stressing or failure, such as: net lifting, fish transfer, removal of mortalities, grading/harvesting, net washing, net replacement, towing operations.

7. Pen Design

The pen system is taken to be the cage superstructure and flotation rings or units. The pen system shall be designed to structurally withstand maximum design loads acting on the pen.

Appropriate load factors shall be applied to estimated loads on the pen (established in Section 5), to arrive at the maximum design loads. Appropriate material factors shall be applied to yield strength values in providing for sufficient reserve structural capacity in materials used.

The pen shall be designed to structurally withstand loadings from direct wave, wind and current actions on the pen and loadings transferred to it from the net and net weighting system, and loadings from the mooring system.

Pen flotation rings, or units, shall have sufficient redundant flotation to prevent sinking in case of damage.

The following elements, as appropriate, shall be included in the pen design assessment: flotation rings / units, brackets, stanchions, hand rail, walkways, secondary chains, net connection points, mooring rope connection points, fender units. Any other relevant elements shall be included.

Allowance shall be made for wave forces on flotation rings/units, wind loading on cage superstructure, current forces on sub surface elements and for the mooring forces transferred to the pen via mooring connections.

In addition, the designer shall check that the pen is capable of withstanding foreseeable operational loadings, such as those caused by vessels mooring alongside, by cage towing and by accidental collision of workboats.

The designer shall make provision for the safety of fish farm workers accessing the pen, and operating at the farm[4], taking account of appropriate H&S legislation and guidance.

[4] Note that, whereas this protocol primarily addresses structural design requirements to prevent structural failure and/or fish escape, there is an onus on Designers to design for the safety of operators of the fish-farm and to consider in the design the conditions under which the farm may or may not be safe for operators to work. In addition, Designers shall consider, and build into the design, the consequences for the structural integrity of the structure and the potential for escape of fish under conditions where the structure is inaccessible, including, for example, for repair works to be carried out under poor weather conditions. Consideration of site suitability for the proposed operations will be an important element in this respect and shall form part of the Design Process.

8. Mooring Design

The mooring system shall be designed to structurally withstand the maximum design loads acting on the mooring system.

Appropriate load factors shall be applied to the estimated loads on the moorings (established in Section 5), to arrive at the maximum design loads. Appropriate material factors shall be applied to yield strength values in providing for sufficient reserve structural capacity in materials used.

The mooring system shall be designed to structurally withstand loadings transferred to it from the cage pen(s) and nets, as well as current drag forces directly acting on the mooring system and to safely transfer the applied loadings to anchors at seabed level.

All main components in the mooring system such as mooring ropes and chains, grid ropes, bridles, mooring buoys, anchors and all load bearing connections, such as shackles, swivels, links and chain plates, shall be designed to withstand the maximum calculated design loadings. Appropriate provision shall be made at all connection points to resist cyclical loading, fatigue and abrasion damage. Fittings such as thimbles and ferrules, etc. shall be of suitable design. Each mooring element and fitting shall have a stated minimum load capacity requirement arising from the design.

In addition to hydrodynamic induced loadings the designer shall check that mooring system components are capable of withstanding all foreseeable operational loadings, such as those caused by positioning, pre-tensioning, relocating mooring systems or collision damage with vessels. Consideration shall also be given in the design for an appropriate level of redundancy to cater for limited damage to parts of the mooring system, such as anchors or bridle ropes, and still allow the system to operate satisfactorily.

Provision shall be made in designing moorings to allow for complete removal of the mooring system, including anchors, from the site at decommissioning stage.

9. Review of Structural Design

A review of the structural design of the finfish farm shall be carried out by a Competent Person as defined under Section 1, when there is:

a) significant change proposed to the structure

If there is a proposal to significantly change farm layout, or change the size/type of any main structural element of the farm or significantly modify a main structural element of the farm, the structural integrity of the farm as previously designed may be affected and the farm design shall be formally reviewed by a Competent Person.

The outcome of the review and details of associated redesign work, where it arises, shall be summarised in a Design Review Statement. Where the earlier design is to be significantly changed or replaced, a new set of revised drawings to a similar level of detail to that submitted at earlier detailed design stage shall be produced and kept in the design record for the farm.

It is a condition in the marine finfish aquaculture licence template that any proposed material change to the equipment to be used during the licensing period will require written confirmation by a Chartered Engineer that the proposed change has been designed with skill, care, diligence and professional conduct reasonably to be expected from a designer with the qualifications and experience suitable for the design work involved. The written confirmation should be included in the design record for the farm.

b) periodic review of performance

The design of the farm shall be subject to periodic review in light of its structural performance and containment record to date. An assessment shall be carried out by a Competent Person at intervals of not more than 5 years to establish what redesign if any is required. In the event that redesign is not considered necessary by the Competent Person it is sufficient for the design record to show by written confirmation of the Competent Person that the detailed design of the net, pen and moorings as currently configured at the licensed site meets this protocol for structural design at that review date.

c) structural or containment failure

Should a structural failure or related containment failure occur a review of the design of the farm or components thereof shall be carried out by the licence holder. The licence holder shall assign a Competent Person to carry out the design review. The outcome of any such design review shall be recorded in the design record for the farm.

10. Maintenance of Structural Design Records

Appropriate design records shall be kept for each marine finfish farm site.

At the various stages in the structural design history of a marine finfish farm - from preliminary design onwards - there is a requirement in this protocol for the design history of the farm site to be recorded in reasonable detail and to be updated on an ongoing basis.

The protocol sets out the requirements for design information to be submitted for approval to the licensing authority: at licence application and pre-deployment stages. The protocol requires that copies of design statements, including sets of drawings, are to be retained in a design record for the farm.

The design record shall include: application stage preliminary design details as outlined in Section 7; pre-deployment detailed design information outlined in Section 8; and, where appropriate, review associated design data as outlined in Section 9. The design record shall include drawings for each stage, as appropriate.

This design record information shall be maintained by the licence holder in a Design Record File. The development of the design, later design changes and other information shall be recorded appropriately and in chronological order. The Design Record File shall be made available for inspection by authorised persons.

Note: This protocol is the guidance document on structural design standards for marine finfish farms at this time. The document will be subject to review and amendment as required. It is anticipated this protocol is likely to be replaced by a detailed technical standard at an appropriate time in the future.

APPENDIX

Standard of Drawings

All drawings showing the structural design of the marine finfish farm shall be drafted to a professional engineering standard. They shall include the following details:

- Farm Company name / logo
- Engineer's Name / Logo
- Project Title
- Drawing Title
- Drawing Number (plus revision version as appropriate)
- Drawing status
- Scales in use (for each drawing detail)
- Scale at sheet size or scale bar as appropriate
- Drawing date
- Draughtsman's and Approver's name, initial and dates
- Drawing notes as appropriate

Preliminary Design Drawing Requirements

Drawings showing the preliminary design will include the following as a minimum:

a) site location map and site location chart, typically 1: 10560 scale, or larger; these shall show the site boundary[5], the farm plan layout, the proposed position and orientation of structures within the site, nearby coastline, landmarks, features (as appropriate to the scale);

b) plan layout of the finfish farm, typically 1: 2000 scale, or larger, showing the superstructure and sub-surface components of the farm – flotation rings or units, walkways, buoys, feed barge, top net supports, the mooring system layout, the expected anchor positions - all major component materials, dimensions shall be specified on the drawing or in accompanying text notes;

c) cross-sectional elevation, typically 1: 2000 scale, or larger, along the principal axes (longitudinal and lateral) of the marine farm, showing superstructure and sub-surface components of the farm relative to mean sea level; and showing expected position of mooring components and anchors; seabed profile to be shown and relevant tidal information[6] .

Detailed Design Drawing Requirements

Drawings showing the detailed design will include a), b) and c) above, updated as required to show the detailed design - plans and elevations of the marine farm [b) and c)] shall be drawn to a scale suitable to show the requisite level of detail (typical scale required 1:1000 or larger).

The following additional drawings will be required:

d) cross-sectional view at 1: 250 scale of representative single cage unit(s) showing all principal components of the pen, net and moorings in greater detail; detailed dimensions shall be included e.g. relevant diameters, widths, thicknesses

e) drawing details of particular items where needed to fully illustrate the design e.g.: net weighting system detail, mooring grid junction detail, bridle rope assembly detail.

[5] It is important that all structures including anchors are fully within the proposed licensed site boundary.

[6] This shall include HAT, MSL and LAT. The recommended level datum to be used is Chart Datum for that area. Where scaling may be an issue for clarity, tidal levels may be shown in a drawing note.