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DEPARTMENT OF THE ARMY
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Regulation
No. 1110-2-8159

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Engineering and Design
LIFE CYCLE DESIGN AND PERFORMANCE

1. Purpose.

This regulation defines engineering policies for selection of all systems, components, and materials for Civil Works projects, on the basis of their long-term performance.

2. Applicability.

This regulation applies to all USACE commands having responsibility for Civil Works projects.

3. Reference. ER 1110-2-1150, Engineering and Design for Civil Works Projects.

4. Distribution.

This regulation is approved for public release, distribution is unlimited.

5. Background.

a. Most Civil Works projects represent major infrastructure investments for the nation, and are likely to remain in use indefinitely. Therefore, in addition to cost considerations, planning and design decisions need to be based on a consideration of the long-term performance of the project. For example, some projects have utilized higher cost silica fume concrete for stilling basins because the improved abrasion resistance can reduce the need for expensive future repairs. Despite the higher first cost, some projects have used positive cutoff walls rather than relief wells which may have been less reliable and would have required future maintenance to ensure continued performance. Other districts have used corrugated metal pipes in the outlet works of dams with salt-laden water, and have proposed using a steel lock structure in the brackish waters along the southern coast of the United States. The experience of these districts has shown that steel structures located in salty soils and brackish waters would have drastically reduced the project service life. Even with protective coatings, these structures would probably be unable to provide the 50-year life commonly assumed for economic analysis of project benefits. Also, the replacement costs for these types of structures could be prohibitive when considering necessary measures to prevent disruption of the project.

b. Previous planning and design efforts have been inconsistent in their treatment of life cycle design. Frequently the long-term performance, reliability, and durability of project materials, components, and systems have not been considered during project development.

c. Repair or replacement of deteriorating projects is a significant expense. Funding constraints may result in the deferral of critical project repairs, resulting in reduced project reliability.

d. Risk-based methods are being incorporated into project evaluations for many of the planning, design, and operation programs. Consideration of long-term performance or deterioration is an essential element of risk assessment.

6. Policy.

a. Responsibility. Design engineers are responsible for implementing life cycle design concepts into the project development process. These requirements also apply to designs performed by architect-engineer firms and to design-build contracts.

b. Requirements. Engineering decisions should not be made solely to minimize first costs, nor to maximize reliability regardless of cost. Design engineers shall use life cycle design as the basis for selection of all project elements such as materials, structural systems, mechanical equipment, and scour protection on all projects. These design decisions will be consistent throughout all project phases, including value engineering studies, and will be based on a minimum project service life of 100 years for major infrastructure projects such as locks, dams and levees. Products with a service life less than the project service life may be used only when a comparison demonstrates reduced life cycle costs. This analysis will include all necessary costs for performing the appropriate repairs and rehabilitation of those products while the project remains in operation. For example, major structural elements are usually extremely difficult and expensive to replace, and these will normally be designed to last for the full project service life. However, many mechanical components are easily replaced, and it is usually appropriate to select a component with a shorter product service life, and replace it several times during the project service life. When replacement or rehabilitation of project elements would result in temporary loss of project function, the lost benefits should also be included in the life cycle cost evaluation.

c. Innovations. Design engineers shall consider the use of innovative products or systems for use in new projects and in rehabilitation or replacement of elements of existing projects. When evaluating innovative products, the design engineer must often rely on professional judgement to determine expected product service life. Initial manufacturer's tests do not always identify the types of durability problems which may occur in specific Civil Works applications.

7. Definitions.

a. Project service life. Project service life is the length of time a project will remain in use to provide its intended function. This will often exceed the time period used for economic analysis of project benefits and costs as the basis for project authorization. Major Civil Works projects can have an indefinite service life. Several cycles of component rehabilitation or replacement may be required to maintain the project's service life.

b. Product service life. Product service life is the length of time an individual component can be expected to remain useable, without a major rehabilitation or replacement. Many products have a service life shorter than the required project service life, therefore causing significant additional costs during the life of the project. The product service life for materials and commercial products will be determined by evaluating the field performance of similar products used on existing Corps projects, and adjusted for the local environmental exposure. (As an example, the product service life of steel products can be significantly reduced by the specific chemistry of the soil and water to which it is exposed.) Therefore, districts will need to record the operational, maintenance and inspection histories of key project elements. When product service life is not available from USACE criteria or district historical files, designers should use other USACE reports and data, or data from an independent product testing group.

c. Life cycle design. Life cycle design means that selection of project elements are based on a combination of life cycle costs and the long-term performance of the materials, components, and systems. These decisions must ensure project integrity throughout the project's service life, and result in reasonable ownership requirements for inspection, evaluation, maintenance, repair, rehabilitation, and replacement.

d. Life cycle costs. Life cycle costs include the initial project investment, and costs for operation, maintenance, repair, rehabilitation, and replacement. Estimates for future rehabilitation or replacement must include the costs of all related work. For example, it may be necessary to construct temporary facilities to ensure continued project function during replacement. For comparison purposes, evaluation of life cycle costs should include a calculation of the present worth, based on constant dollar analysis, and using appropriate discount rates for future costs. Discount rates are set by the Office of Management and Budget. Designers should evaluate life cycle costs over the expected project service life.

8. Planning and Design Phases.

a. General. Life cycle design should be used during all phases of project development for all decisions on selection of project elements. Design engineers should use proven technology that will assure the use of high quality products, and should carefully evaluate the usefulness of innovative products or systems. The analysis will consider the product service life of each project element, and account for its economic differences related to inspection, maintenance, repair, and rehabilitation.

b. Planning. Engineering requirements during project planning phases are described in ER 1110-2-1150. Engineering design during the early project stages is primarily devoted to the development of the overall project concepts and project costs. Design engineers need to make reasonable selections of systems, components, and materials early in the project development. These selections will ensure that adequate cost estimates are developed during these early planning phases. Design engineers are to use materials and project components with a proven history of long-term reliable performance. When systems, components, and materials with a short product service life are selected, the designer must thoroughly evaluate that element's maintenance, repair, and replacement methods and costs.

(1) Operation. Different products or materials which provide the same function may have different requirements for normal operation and maintenance. When this is the case, the different costs for these requirements should be included in the life cycle comparison. For example, painting or lubrication requirements, handling of hazardous materials, or compliance with various environmental regulations can add significant costs to project operations.

(2) Future Repairs. Calculation of life cycle costs for future repairs is challenging because future conditions, materials, constuction methods, and related construction requirements are generally less certain than those used to develop the initial construction cost estimates. Designers are responsible for selecting quality products, and must use sound engineering judgement when considering future repairs since these requirements can be highly uncertain during early project planning.

(3) Maintenance Construction. All temporary construction measures necessary to facilitate major project maintenance, repair, and rehabilitation will be identified in the engineering appendix to all decision documents. This appendix will describe the required rehabilitation and reconstruction scenario necessary to achieve the project's service life.

c. Design. Most of a project's feature design occurs after the project is authorized. Therefore, engineering during the design phase will include detailed comparisons of alternative systems, components, or materials, and will optimize the project's life cycle performance and cost. Designers should identify the likely maintenance, repair and replacement requirements for each scenario, including any need for dewatering or temporary cofferdams. The contract specifications should clearly identify appropriate requirements for these selected products or materials. When the service life of a critical product can be extended through the use of specific construction quality controls, such controls should be implemented in the contract documents and in design notes to the field. Designers should develop a monitoring and inspection plan during the project's design phase to assure that proper operation and maintenance activities can be performed throughout the project's service life. Such a plan will identify the inspections to be performed, the frequency of inspections, and the evaluation criteria. The project's design limitations will be identified in all design documentation, and should be included in the project's O&M manual. These design requirements apply to both in-house designs and architect-engineer designs, and such requirements should be included in design-build contracts.

d. Risk. Risk assessment can be a useful tool to supplement evaluation of options to ensure life cycle performance. Potential risks and resulting consequences should be identified for each option under consideration. Risks might include: the probability of failure of a component, unexpected maintenance expenditures, premature need for rehabilitation or replacement, failure of temporary protection measures during planned rehabilitation or replacement.

9. Emerging Systems and Materials.

a. Opportunities. Designers and manufacturers frequently develop new solutions for existing problems. To improve service to our customers by reducing costs and improving performance, the Corps must take advantage of these new solutions. However, unproven technologies should be used with caution, and should be evaluated within the context of caution, and should be evaluated within the context of life cycle performance.

b. Demonstration Projects. Innovative and emerging technologies can be evaluated for corps-wide use through monitoring of demonstration projects. Districts considering the use of an innovative or emerging technology should work with MSC and CECW-E staff to gain concurrence that a demonstration project is appropriate. The district should then convene a technology evaluation board with appropriate reprentatives from the district, MSC, CECW-E, and the cost sharing partner. The board should gather, evaluate and submit the following information through the MSC to CECW-E to facilitate Corps-wide acceptance of the innovative technology.

(1) Determine where the proposed system and/or material has been used previously (other than industry research), and how it has performed.

(2) Identify the key performance features being tested by the demonstration project, and the expected outcome.

(3) Provide a description of the monitoring plan to be used during the demonstration project period.

(4) Periodically assess performance of the new technology.

FOR THE COMMANDER:

OTIS WILLIAMS
Colonel, Corps of Engineers
Chief of Staff