Rehabilitation Of Concrete Structures

Rehabilitation Of Concrete Structures Rehabilitation of concrete structures is a critical aspect of maintaining the safety, functionality, and longevity of infrastructure. Over time, concrete structures such as bridges, buildings, tunnels, and dams are subjected to various forms of deterioration caused by environmental factors, load conditions, and material aging. Proper rehabilitation not only extends the service life of these structures but also ensures they meet current safety standards and performance requirements. This comprehensive guide explores the essential aspects of concrete structure rehabilitation, including causes of deterioration, inspection and assessment, rehabilitation methods, and best practices for long-term maintenance. Understanding the Need for Concrete Structure Rehabilitation Common Causes of Concrete Deterioration Concrete deterioration can result from a multitude of factors, which can be broadly categorized as: Environmental Factors: Exposure to moisture, freeze-thaw cycles, chloride ingress, carbonation, and chemical attacks can weaken concrete over time. Structural Loadings: Excessive or unexpected loads can induce cracks and damage, compromising structural integrity. Material Aging: Natural aging processes can lead to loss of concrete strength and durability. Poor Construction Practices: Inadequate curing, improper mix proportions, or substandard workmanship can accelerate deterioration. Corrosion of Reinforcement: Steel reinforcement embedded in concrete can corrode if protective cover is compromised, leading to cracking and spalling. Impacts of Deterioration Ignoring signs of deterioration can result in: Reduced load-carrying capacity Increased safety risks for users and occupants Higher repair costs if issues worsen Potential failure of entire structural systems Decreased service life and increased lifecycle costs 2 Inspection and Assessment of Concrete Structures Visual Inspection The initial step involves a thorough visual assessment to identify visible signs of damage such as cracks, spalling, discoloration, efflorescence, and corrosion stains. Non-Destructive Testing (NDT) NDT methods provide valuable data without damaging the structure: Ultrasonic Pulse Velocity (UPV): Measures concrete quality and detects internal flaws. Rebound Hammer Test: Estimates surface hardness and strength. Ground Penetrating Radar (GPR): Identifies embedded reinforcement and voids. Infrared Thermography: Detects delaminations and moisture ingress. Sampling and Laboratory Testing Collected core samples are tested for compressive strength, moisture content, and chemical composition, providing precise data for designing rehabilitation strategies. Structural Analysis Advanced analysis techniques evaluate load capacity, crack patterns, and structural stability based on inspection data. Methods of Rehabilitation for Concrete Structures Surface Treatments and Repairs These are the most common and straightforward rehabilitation methods: Crack Injection: Seals cracks to prevent ingress of damaging agents. Patch Repairs: Removes deteriorated concrete and replaces it with compatible material. Surface Coatings: Protects concrete from environmental exposure and reduces permeability. Structural Reinforcement Techniques When existing structures lack sufficient capacity, reinforcement methods are employed: External Post-Tensioning: Adds prestress to improve load capacity. Fiber-Reinforced Polymer (FRP) Strengthening: Bonded composites increase 3 strength and ductility. Steel Plate Bonding: Plates are bonded to structural elements to provide additional support. Material-Based Rehabilitation

Methods These involve replacing or augmenting existing concrete: Overlay and Overlay Repair: Applying a new layer of concrete or mortar over existing surfaces to restore surface integrity. Shotcrete: Sprayed concrete used for repairs and reinforcement of irregular surfaces. Epoxy and Polymer-Based Repairs: Use of high-strength adhesives for bonding new concrete or filling voids. Corrosion Protection and Control Since corrosion of reinforcement is a leading cause of deterioration, specific measures include: Reinforcement Encapsulation: Applying corrosion inhibitors or protective coatings on reinforcement. Cathodic Protection: Using electrochemical methods to prevent steel corrosion. Improving Concrete Cover: Increasing cover thickness to reinforce the barrier against aggressive agents. Choosing the Right Rehabilitation Strategy Factors Influencing Decision-Making Selecting an appropriate rehabilitation method depends on: Extent and type of damage Structural importance and load requirements Environmental conditions Available budget and resources Desired lifespan and performance goals Design Considerations Rehabilitation designs should be compatible with existing structures, ensuring minimal disruption and maximal durability. 4 Best Practices for Effective Concrete Rehabilitation Preparation and Surface Cleaning Proper cleaning and preparation of the surface ensure good bonding of repair materials. Use of Compatible Materials All repair materials should match the physical and chemical properties of existing concrete to prevent issues like delamination. Quality Control and Testing Regular testing during and after rehabilitation ensures that repairs meet specified standards. Monitoring and Maintenance Post-rehabilitation, ongoing monitoring and maintenance are essential to detect early signs of deterioration and address them promptly. Long-Term Maintenance and Preservation of Concrete Structures Scheduled Inspections Routine inspections help identify emerging problems before they escalate. Environmental Protection Measures Implementing protective coatings, drainage improvements, and environmental controls can reduce exposure to damaging agents. Preventive Maintenance Activities such as cleaning, resealing, and minor repairs prolong the lifespan of rehabilitated structures. Documentation and Record-Keeping Maintaining detailed records of inspections, repairs, and materials used aids future maintenance planning. Conclusion Rehabilitation of concrete structures is an essential component of infrastructure 5 management, ensuring safety, durability, and cost-effectiveness. By understanding the causes of deterioration, conducting thorough assessments, selecting appropriate repair methods, and adhering to best practices, engineers and maintenance professionals can extend the service life of vital structures. Investing in proper rehabilitation not only preserves the structural integrity but also enhances resilience against future challenges, ultimately safeguarding public safety and economic interests. For optimal results, always consult with experienced structural engineers and materials specialists to develop tailored rehabilitation strategies that meet specific project requirements and environmental conditions. QuestionAnswer What are the common causes of deterioration in concrete structures that require rehabilitation? Common causes include corrosion of reinforcement, freeze-thaw cycles, chemical attacks (like sulfate attack), physical damage, and inadequate design or construction practices. What are the primary methods used in the rehabilitation of deteriorated concrete structures? Primary methods include surface repairs (patching, sealing), cathodic protection, concrete overlays, corrosion inhibitors, and full or partial replacement of damaged sections. How does corrosion of reinforcement impact the structural integrity of concrete? Corrosion causes expansion of reinforcement bars, leading to cracking, spalling, and loss of bond between concrete and steel, which compromises the load- carrying capacity of the structure. What role

does nondestructive testing (NDT) play in the rehabilitation process? NDT methods like ultrasonic testing, ground- penetrating radar, and half-cell potential measurements help assess the extent of damage, locate corrosion, and inform effective repair strategies without damaging the structure. When is it necessary to consider complete replacement versus repair of a concrete structure? Complete replacement is considered when the structure has extensive damage, severe reinforcement corrosion, or structural safety is compromised, whereas repairs are suitable for localized or minor deterioration. What advancements in materials are improving concrete rehabilitation techniques? Innovations include high-performance repair mortars, corrosion-inhibiting coatings, fiber-reinforced composites, and self-healing concrete materials that extend the lifespan of rehabilitated structures. How important is early intervention in the rehabilitation of concrete structures? Early intervention can prevent minor damages from progressing into major structural issues, reducing repair costs, extending service life, and ensuring safety and durability. 6 What are the key considerations for ensuring the durability of rehabilitated concrete structures? Key considerations include proper surface preparation, compatibility of repair materials, protection against future environmental attacks, and implementing protective coatings or cathodic protection as needed. Rehabilitation of concrete structures: Ensuring Durability, Safety, and Longevity Concrete remains one of the most widely used construction materials worldwide, prized for its strength, durability, and versatility. However, like all materials, concrete is susceptible to deterioration over time due to environmental exposure, load stresses, and inherent material flaws. The process of rehabilitation of concrete structures has become an essential aspect of civil engineering, aimed at restoring, strengthening, and prolonging the service life of existing infrastructure. This comprehensive review explores the critical facets of concrete rehabilitation, including causes of deterioration, assessment methods, repair techniques, and emerging innovations. --- Understanding the Need for Concrete Rehabilitation Reasons for Concrete Deterioration Concrete deterioration can arise from a variety of factors, often acting synergistically: - Environmental Factors: - Carbonation: The ingress of carbon dioxide reduces the pH of concrete, leading to corrosion of embedded steel reinforcement. - Chloride Attack: Chloride ions, primarily from de-icing salts or seawater, penetrate the concrete and induce corrosion. - Freeze-Thaw Cycles: Repeated freezing and thawing cause internal stresses and surface scaling. - Chemical Attack: Exposure to aggressive chemicals like sulfates can weaken concrete. - Mechanical Factors: - Overloading beyond design capacity causes cracks and structural fatigue. - Impact damage from accidents or natural events. - Material and Construction Defects: - Poor mix design, inadequate curing, or improper placement can predispose concrete to early deterioration. - Reinforcement corrosion due to inadequate cover or corrosion inhibitors. - Aging and Wear: - Long-term exposure to traffic, vibrations, and environmental conditions naturally degrades concrete. Impacts of Deterioration on Structural Integrity Deterioration compromises the load-bearing capacity, safety, and aesthetics of concrete structures. Left unaddressed, it can lead to catastrophic failures, increased maintenance costs, and shortened lifespan of infrastructure. Therefore, timely diagnosis and effective rehabilitation strategies are crucial. --- Assessment and Diagnosis of Concrete Deterioration Rehabilitation Of Concrete Structures 7 Visual Inspection The first step involves comprehensive visual surveys to identify cracks, spalling, efflorescence, exposed reinforcement, and surface discoloration. Non-Destructive Testing (NDT) Advanced techniques allow evaluation without damaging the structure: - Ultrasound Pulse Velocity

(UPV): Detects internal flaws. - Rebound Hammer Test: Estimates surface hardness and concrete strength. - Ground Penetrating Radar (GPR): Locates embedded reinforcement and voids. - Infrared Thermography: Identifies moisture ingress and delamination. Laboratory Testing Sample extraction and analysis provide detailed information: - Compressive strength tests - Chemical analysis for sulfate, chloride content - Reinforcement corrosion assessment via half-cell potential measurement Structural Analysis Finite element modeling and load testing help determine residual capacity and safety margins, guiding rehabilitation decisions. --- Principles and Objectives of Concrete Rehabilitation Rehabilitation aims to: - Restore structural integrity and load capacity - Protect reinforcement from corrosion - Improve durability against environmental threats - Enhance aesthetics - Minimize downtime and future maintenance costs Effective rehabilitation involves selecting appropriate repair techniques tailored to the type and extent of deterioration, structural importance, and environmental conditions. --- Common Techniques for Concrete Rehabilitation Surface Repairs Used for minor surface defects: - Cleaning: Removing dirt, loose debris, and contaminants via high-pressure water jetting or sandblasting. - Crack Repair: - Routing and sealing: For small cracks. - Epoxy injections: Filling active or dormant cracks. - Surface Coatings and Sealants: - Protective paints, epoxy overlays, or penetrating sealers to prevent ingress of harmful agents. Rehabilitation Of Concrete Structures 8 Structural Repairs For significant deterioration affecting load capacity: - Overlay Methods: - Applying a new layer of concrete or mortar to restore surface profile and protect underlying concrete. - Fiber-Reinforced Polymer (FRP) Wrapping: - Applying composite materials to confine or strengthen existing concrete, particularly in columns and beams. - Advantages include high strength-to-weight ratio, corrosion resistance, and ease of installation. - Steel Plate or Jacketing: - Encasing structural members with steel plates or additional concrete jackets to increase load capacity. Infill and Reconstruction For extensive damage or loss of material: - Partial or Complete Replacement: - Demolition of severely compromised sections followed by new concrete placement. - Shotcrete: - Sprayed concrete used for repairing surfaces, especially in difficult-to-access areas. Corrosion Protection and Prevention Rehabilitation often involves measures to mitigate reinforcement corrosion: - Cathodic Protection: - Applying a small electric current to inhibit corrosion. - Reinforcement Encapsulation: - Using corrosion-inhibiting coatings or sacrificial anodes. --- Innovations and Future Directions in Concrete Rehabilitation Advanced Materials Emerging materials are enhancing repair durability: - Self-Healing Concrete: - Incorporates bacteria or chemical agents that activate upon crack formation to precipitate healing agents. - High-Performance Repair Mortars: - Designed for compatibility, adhesion, and resistance to environmental aggressors. Smart Technologies Integration of sensors and monitoring systems: - Embedding strain gauges, corrosion sensors, and moisture detectors to enable real-time health monitoring. - Facilitates proactive maintenance and reduces unexpected failures. Environmental Considerations Rehabilitation techniques are increasingly focused on sustainability: - Use of recycled aggregates and eco-friendly binders. - Minimizing carbon footprint through efficient repair strategies. Rehabilitation Of Concrete Structures 9 Digital and Robotic Assistance Automation and robotics are transforming rehabilitation: - Robotic scarifying, cleaning, and applying repair materials. - Drones for inspection in inaccessible locations. --- Challenges and Considerations in Concrete Rehabilitation While the advancements are promising, several challenges persist: - Compatibility of Repair Materials: Ensuring that new materials bond well with existing

concrete without causing additional stresses. - Assessment Accuracy: Precise diagnosis is critical; underestimating deterioration can lead to premature failure. - Cost and Disruption: Rehabilitation can be expensive and may require significant downtime. - Environmental Impact: Selecting environmentally sustainable repair methods remains a priority. --- Case Studies and Practical Applications Real-world applications showcase the effectiveness of various rehabilitation strategies: - Restoration of aging bridges with FRP wrapping. - Seismic retrofitting of concrete columns using fiber-reinforced polymers. - Coastal infrastructure protection through cathodic protection and protective coatings. --- Conclusion The rehabilitation of concrete structures is an evolving discipline that combines traditional repair techniques with cutting-edge materials and technologies. As urban infrastructure ages and environmental challenges intensify, the importance of effective, durable, and sustainable rehabilitation methods cannot be overstated. A multidisciplinary approach—integrating thorough assessment, innovative repair solutions, and proactive maintenance—is essential to extend the service life of concrete structures, ensuring safety, functionality, and resilience for decades to come. --- References and Further Reading - Neville, A. M. (2012). Properties of Concrete. Pearson. - Mehta, P. K., & Monteiro, P. J. M. (2014). Concrete: Microstructure, Properties, and Materials. McGraw-Hill. - ASTM Standards for Concrete Repair and Rehabilitation. - Recent journal articles on innovative repair materials and techniques. --- Author’s Note: The field of concrete rehabilitation is continually advancing, driven by technological innovations and the pressing need for sustainable infrastructure management. Staying informed of the latest research and adopting best practices are key to effective rehabilitation strategies. concrete repair, structural assessment, crack injection, concrete restoration, concrete curing, corrosion protection, structural strengthening, concrete surface treatment, durability enhancement, repair materials

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for over sixty years the primary source for design of concrete structures now revised and updated simplified design of concrete structures eighth edition covers all the latest commonly used concrete systems practices and research in the field reinforced with examples of practical designs and general building structural systems updated to conform to current building codes design practices and industry standards simplified design of concrete structures eighth edition is a reliable easy to use handbook that examines a wide range of concrete structures building types and construction details it includes a wealth of illustrations expanded text examples exercise problems and a helpful glossary highlights of this outstanding tool include its use of the current american concrete institute building code for 2005 aci 318 and the load and resistance factor design lrfd method of structural design fundamental and real world coverage of concrete structures that assumes no previous experience valuable study aids such as exercise problems questions and word lists enhance usability

structural concrete members often show great deviation in structural performance from that predicted by the current code of practice in certain cases the predications considerably underestimate the capabilities of a structure or member while in others the predictions are unsafe as they overestimate the member s ability to perform in a prescribed manner clearly a rational and unified design methodology is still lacking for structural concrete this book presents a simplified methodology based on calculations which are quick easily programmable and no more complex than those required by the current codes it involves identifying the regions of a structural member or structure through which the external load is transmitted from its point of application to the supports and then strengthening these regions as required as most of these regions enclose the trajectories of internal compression actions the technique has been called the compressive force path method ultimate limit state design for concrete structures will provide designers with a practical and easily applied method for the design of a concrete structure which is fully compatible with the behaviour of concrete as described by valid experimental evidence at both the material and structural level

based on the latest version of designing codes both for buildings and bridges gb50010 2010 and jtg d62 2004 this book starts from steel and concrete materials whose properties are very important to the mechanical behavior of concrete structural members step by step analysis of reinforced and prestressed concrete members under basic loading types tension compression flexure shearing and torsion and environmental actions are introduced the characteristic of the book that distinguishes it from other textbooks on concrete structures is that more emphasis has been laid on the basic theories of reinforced concrete and the application of the basic theories in design of new structures and analysis of existing structures examples and problems in each chapter are carefully designed to cover every important knowledge point as a basic course for undergraduates majoring in civil engineering this course is different from either the previously learnt mechanics courses or the design courses to be learnt compared with

mechanics courses the basic theories of reinforced concrete structures cannot be solely derived by theoretical analysis and compared with design courses this course emphasizes the introduction of basic theories rather than simply being a translation of design specifications the book will focus on both the theoretical derivations and the engineering practices

1 introduction 2 materials 3 flexural analysis and design of beams 4 shear and diagonal tension in beams 5 bond anchorage and developmental length 6 serviceability 7 analysis and design for torsion 8 short columns 9 slender columns 10 strut and tie models 11 design of reinforcement at joints 12 analysis of indeterminate beams and frames 13 analysis and design of slabs 14 yield line analysis for slabs 15 strip method for slabs 16 footings and foundations 17 retaining walls 18 concrete building systems 19 prestressed concrete 20 seismic design appendix a design aids appendix b si conversion factors inch pound units to si unites

topics discussed in these papers include developments in materials and methods for repair of existing structures and use in new construction the themes of the seminar are materials development and practical applications

this revised fully updated second edition covers the analysis design and construction of reinforced concrete structures from a real world perspective it examines different reinforced concrete elements such as slabs beams columns foundations basement and retaining walls and pre stressed concrete incorporating the most up to date edition of the american concrete institute code aci 318 14 requirements for the design of concrete structures it includes a chapter on metric system in reinforced concrete design and construction a new chapter on the design of formworks has been added which is of great value to students in the construction engineering programs along with practicing engineers and architects this second edition also includes a new appendix with color images illustrating various concrete construction practices and well designed buildings the aci 318 14 constitutes the most extensive reorganization of the code in the past 40 years references to the various sections of the aci 318 14 are provided throughout the book to facilitate its use by students and professionals aimed at architecture building construction and undergraduate engineering students the scope of concepts in this volume emphasize simplified and practical methods in the analysis and design of reinforced concrete this is distinct from advanced graduate engineering texts where treatment of the subject centers around the theoretical and mathematical aspects of design as in the first edition this book adopts a step by step approach to solving analysis and design problems in reinforced concrete using a highly graphical and interactive approach in its use of detailed images and self experimentation exercises concrete structures second edition is tailored to the most practical questions and fundamental concepts of design of structures in reinforced concrete the text stands as an ideal learning resource for civil engineering building construction and architecture students as well as a valuable reference for concrete structural design professionals in practice

this book is prepared according to the 2011 aci code for buildings and aashto lrfd specifications for bridges the units used throughout the presentation are the si units according to the official system of units in pakistan as in part i of the same series of books it is tried that the three main phases of structural design namely load determination design calculations and detailing together are

introduced to the beginner besides reinforced concrete design basics of formwork design plain concrete properties and repair rehabilitation of concrete structures are also presented this book is useful with the 1st part of the same book suggestions for further improvement of the presentation will be highly appreciated and will be incorporated in the future editions

the second edition of the structural concrete textbook is an extensive revision that reflects advances in knowledge and technology over the past decade it was prepared in the intermediate period from the cep fip model code 1990 mc90 to fib model code for concrete structures 2010 mc2010 and as such incorporates a significant amount of information that has been already finalized for mc2010 while keeping some material from mc90 that was not yet modified considerably the objective of the textbook is to give detailed information on a wide range of concrete engineering from selection of appropriate structural system and also materials through design and execution and finally behaviour in use the revised fib structural concrete textbook covers the following main topics phases of design process conceptual design short and long term properties of conventional concrete including creep shrinkage fatigue and temperature influences special types of concretes such as self compacting concrete architectural concrete fibre reinforced concrete high and ultra high performance concrete properties of reinforcing and prestressing materials bond tension stiffening moment curvature confining effect dowel action aggregate interlock structural analysis with or without time dependent effects definition of limit states control of cracking and deformations design for moment shear or torsion buckling fatigue anchorages splices detailing design for durability including service life design aspects deterioration mechanisms modelling of deterioration mechanisms environmental influences influences of design and execution on durability fire design including changes in material and structural properties spalling degree of deterioration member design linear members and slabs with reinforcement layout deep beams management assessment maintenance repair including conservation strategies risk management types of interventions as well as aspects of execution quality assurance formwork and curing the updated textbook provides the basics of material and structural behaviour and the fundamental knowledge needed for the design assessment or retrofitting of concrete structures it will be essential reading material for graduate students in the field of structural concrete and also assist designers and consultants in understanding the background to the rules they apply in their practice furthermore it should prove particularly valuable to users of the new editions of eurocode 2 for concrete buildings bridges and container structures which are based only partly on mc90 and partly on more recent knowledge which was not included in the 1999 edition of the textbook

an in depth guide to using concrete as a building material many of the earliest books particularly those dating back to the 1900s and before are now extremely scarce and increasingly expensive we are republishing these classic works in affordable high quality modern editions using the original text and artwork

in recent years knowledge of concrete and concrete structures has increased as has its applications new types of concrete challenged scientists and engineers and ecological constraints encouraged the implementation of life cycle design of concrete structures moving the focus more and more to maintenance and uprating of structures and since bui

17 2 stress fields for simple structures 2 1 introduction in this chapter the behavior and strength of simple structures made of rein forced or prestressed concrete is investigated with the aid of stress fields in particular the webs and flanges of beams simple walls brackets bracing beams and joints of frames are investigated by this means the majority of design cases are already covered in reality all structural components are three dimensional here however components are considered either directly as two dimensional plate elements i e the plane stress condition with no variation of stress over the thickness of the element or they are subdivided into several plates since two dimensional structural elements are statically redundant it is possible for a particular loading to be in equilibrium with many theoretically an infinite number of stress states if the lower bound method of the theory of plasticity is employed then an admissible stress field or any combination of such stress fields may be selected in chapter 4 it is shown that this method is suitable for the design of reinforced concrete structures and the consequence of the choice of the final structural system on the structural behavior is dealt with in detail the first cases of the use of this method date back to ritter 6 and morsch 4 who already at the beginning of the century investigated the resultants of the internal stresses by means of truss models

concrete structures must be designed not only to be safe against failure but also to perform satisfactorily in use this book is written for practising engineers and students and focuses on design methods for checking deflections and cracking which can affect the serviceability of reinforced and prestressed concrete structures the authors present accurate and easy to apply methods of analysing immediate and long term stresses and deformations these methods allow designers to account for variations of concrete properties from project to project and from country to country making the book universally applicable comprehensively updated this third edition of concrete structures also includes four new chapters covering such topics as non linear analysis of plane frames design for serviceability of prestressed concrete serviceability of members reinforced with fibre polymer bars and the analysis of time dependent internal forces with linear computer programs that are routinely used by structural designers a website accompanies the book featuring three design calculation programs related to stresses in cracked sections creep coefficients and time dependent analysis the book contains numerous examples some of which are worked out in the si units and others in the imperial units the input data and the main results are given in both si and imperial units the book is not tied to any specific code although the latest american and european codes of practice are covered in the appendices

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structural concrete examines the behavior of reinforced and prestressed concrete structures under working load and ultimate load conditions this eight chapter text deals first with the analysis of concrete structures as a particular branch of structural mechanics other chapters explore the empirical methods and the practical design and detailing procedures considerable chapters describe the mechanical behavior of structural concrete with a particular emphasis on the elastic behavior the final chapters examine the behavior of continuous beams frames and slabs these chapters also look into the models for structural concrete this book is intended primarily to undergraduate civil engineering students

the latest edition of this well known book makes available to structural design engineers a wealth of practical advice on effective design of concrete structures it covers the complete range of concrete elements and includes numerous data sheets charts and examples to help the designer it is fully updated in line with the relevant british standards and codes of practice

in finite element design of concrete structures practical problems and their solutions the author addresses this blind belief in computer results by offering a useful critique that important details are overlooked due to the flood of information from the output of computer calculations indeed errors in the numerical model may lead in extreme cases to structural failures as the collapse of the so called sleipner platform has demonstrated

buildings structural design structural systems concretes structures design reinforced concrete prestressed concrete precast concrete factor of safety durability design calculations prestressing steels structural members fire resistance construction materials safety measures approval testing serviceability limits tendons reinforcement lightweight aggregates aggregates

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