Teaching Reform and Practice of "Soil Conservation Plan Development" Course Based on Soil Loss Qualification Guidelines

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Abstract: Soil conservation plan development and soil loss qualification are the core teaching and practice contents for the major of soil water conservation and desertification control, and directly impact the effectiveness of regional ecological governance and the quality of professional talent training. With Inner Mongolia Agricultural University as an example, we systematically analysed the core characteristics, teaching issues, reform pattern, and application results in region-specific scenarios of the Soil Conservation Plan Development course, based on the Guidelines for Soil Loss Qualification in Production and Construction Projects (SL773-2018) and relevant teaching reform practice. The reforms were effectively linked with industry standards and the regional characteristics of wind-water complex erosion in Inner Mongolia, and students' capabilities in plan development, qualification precision control, and practical application were significantly enhanced, through modular course reconstruction, case-based and problem-oriented teaching, integration of virtual simulation and field training, diversified assessment and evaluation, and other reform measures. Finally, given the 'dual-carbon' goal, 3S technology deepening, and interdisciplinary integration trend, the future development direction of the course was discussed so as to provide references for major development in similar universities and colleges and for soil conservation practice in ecologically fragile areas of North China.

Keywords: Teaching Reform; Soil Conservation Plan Development; Soil Loss Qualification Guidelines; Practical Teaching; Inner Mongolia Agricultural University

1. Introduction

Soil erosion is a critical ecological problem that constrains the ecological security and sustainable development of China. The 2022 China Soil and Water Conservation Bulletin showed the national soil erosion area reached 2.6534 million km², and 30,600 km² or 1.15% of soil erosion came from production and construction projects, which became a new major cause of soil erosion [1]. Accurately qualifying soil loss from production and construction projects is a core prerequisite for scientifically distributing prevention and control measures and mitigating ecological risks, and is a statutory technical foundation for soil conservation planning. The Guidelines for Soil Loss Qualification in Production and Construction Projects (SL773-2018) issued by the Ministry of Water Resources in 2018 unifies the standards for pre-construction prediction, in-construction monitoring, and post-construction calculation of soil loss under water and wind forces [2]. It provides standardised technical references for engineering practice, teaching and research in soil conservation, and completely overcomes the limited applicability of traditional analogy and empirical estimation methods [3].

As a core region of China's northern ecological security barrier, Inner Mongolia Autonomous Region spans diverse landscapes (e.g., grasslands, deserts, hills), and is a globally typical region of combined wind and water erosion, where soil erosion is particularly severe [4]. Statistics show the total area of soil erosion in the region reaches 281,000 km2, accounting for 23.5% of its total land area and including 198,000 km2 of wind erosion and 83,000 km2 of water erosion. During production and construction activities (e.g., mining development in grasslands, urban construction at desert edges, building of cross-regional traffic trunk lines), the soil erosion induced by surface disturbance exacerbates ecological vulnerability and directly threatens regional water resource security and the sustainable development of agriculture and animal husbandry. Hence, support from precise qualification technologies and professional governance talents is urgently needed.

The College of Desert Control Science and Engineering, Inner Mongolia Agricultural University, as a talent training base of soil conservation and desertification control in North China, has consistently focused on the ecological governance needs of Inner Mongolia and other arid and semi-arid regions of North China since its establishment, and has constructed a 'theory-practice-regional characteristics' trinity talent training pattern [5]. Specifically, the Soil Conservation Plan Development course and the soil loss qualification module directly align with core job positions in soil conservation monitoring, plan development and engineering supervision, and are key platforms for training the 'local, applied, and professional' qualities of students [6]. However, traditional teaching methods are encountered with such problems as weak alignment between course contents and industry standards, disconnection between theoretical teaching and practical applications in the complex erosion areas of Inner Mongolia, and insufficient integration between qualification techniques and new technologies such as 3S [7,8]. These problems make students unable to accurately apply the Guidelines in complex scenarios.

In summary, this study was centered on the standardised technical framework of the Guidelines for Soil Loss Qualification in Production and Construction Projects (SL773-2018), and deeply integrated the regional ecological characteristics of wind-water complex erosion in Inner Mongolia and the teaching reform practice of the Soil Conservation Plan Development course at Inner Mongolia Agricultural University. It systematically organised the core content system of soil conservation plan development, the standardised process and regionally adapted technologies of soil loss qualification, and specially analysed the key pathways in course teaching reform, such as modular content reconstruction, case-based and virtual simulation integrated teaching, interdisciplinary knowledge integration, and diversified assessment and evaluation. Through typical production and construction project examples, it also verified the application effectiveness and parameter optimisation methods of the Guidelines in complex erosion regions of North China. This study was aimed to refine the curriculum for the soil conservation and desertification control major in colleges and universities, address pain points (e.g., disconnection between theory and practice, inadequate alignment with standards in traditional teaching), and enhance the plan development capability of applied talents and their adaptability to regional ecological governance. It also provides operable technical references for soil conservation plan development and precise soil loss qualification of production and construction projects in ecologically fragile areas of North China, and supports regional ecological security barrier construction and high-quality ecological civilisation.

2. Core Characteristics of Soil Conservation Plan Development Course

Soil Conservation Plan Development is a highly comprehensive and practical course closely related to national policies and regulations, and shows strong contemporary relevance. Its core objective is to use scientific planning of prevention measures to effectively control soil erosion caused by production and construction projects. The College of Desert Control Science and Engineering, Inner Mongolia Agricultural University, has this course as a specialised elective for seniors majoring in Soil Conservation and Desertification Control. With totally 40 class hours and 2 credits, this course is aimed to enhance students' professional knowledge system and innovative thinking and practical skills through systematic teaching and practical training, thus laying a foundation for students to meet professional job requirements.

2.1 Deep Integration of Practicality and Legality

Laws and regulations such as the Water and Soil Conservation Law of People's Republic of China provide that development and construction projects that may cause soil erosion must prepare water conservation plans at early stages of project initiation. Additionally, administrative approval from competent authority is required before construction can commence. These requirements constitute the core legal basis for this course. The contents of plans must systematically analyse potential soil erosion risks, construction feasibility, prevention and control measures, investment estimates, implementation schedule, and management mechanisms from the perspective of water conservation. The contents directly guide the practice of soil erosion prevention and control during project construction. Thus, the core teaching objective of the course focuses on enabling students to proficiently master the key flowchart and practical methods of soil conservation planning. As for career prospects, 32.6%-60.7% of graduates in this major engage in soil conservation planning and related ecological governance jobs. The practical contents of this course closely align with professional application scenarios, and the mastery level of practical skills directly impacts students' employment competitiveness [9].

2.2 Interdisciplinary Comprehensiveness of Knowledge System

The core content of the course is the layout and design of soil conservation measures for production and construction projects. This process requires students to digest and master interdisciplinary knowledge (e.g., soil erosion rationale, soil conservation engineering, ecology, botany, hydrology, water conservation engineering design) and integrate and flexibly apply interdisciplinary knowledge. In other words, the process of soil conservation plan development serves both as a comprehensive test of students' professional basis, and as a key vehicle to help them break down disciplinary knowledge barriers and build a systematic knowledge framework. This process effectively enhances students' deep understanding and comprehensive application ability of professional knowledge.

2.3 Dynamic Diversity and Regional Adaptability of Application Scenarios

Production and construction projects span various domains, including mining, hydropower, transportation, and municipal engineering. Even for the same type of projects, differences in construction scale, geographical location, and topography lead to significant variations in soil erosion sensitivity, constraints, and prevention needs, indicating there is no definite governance pattern to follow [10]. Such reality requires that course teaching shall not be limited to general theories, but must closely integrate with the characteristics of soil erosion in the project region for targeted teaching. For instance, Inner Mongolia is a typical region of wind-water combined erosion, so this course shall incorporate region-specific contents (e.g., qualification of soil-rock mixed loss in grassland mining areas, wind erosion prevention and control technologies at desert edges, and comprehensive management of water erosion in hilly gully regions), so as to align with the differentiated demands of local ecological governance for professionals and highlight the orientation of 'localised' talent training. Thus, the course not only requires students to master basic theories and general methods, but also emphasises the development of their practical abilities to address complex scenarios and design individualised prevention and control plans.

3. Problems in Teaching Soil Conservation Plan Development

Based on the characteristics of the course and regional teaching needs, the traditional teaching pattern has faced three major problems, which severely restrict the quality of talent training and the effectiveness of guideline implementation.

3.1 Abstract Theoretical Knowledge, and Disconnection from Practical Teaching

The course teaching still predominantly follows the traditional 'cramming' and 'one-person show' pattern, where the classroom is centered on the teacher's one-way knowledge delivery and lacks effective teacher-student interaction, forming a 'monophonic' teaching atmosphere. Under this pattern, students passively receive knowledge and can hardly grasp and absorb it deeply, resulting in dull classroom and insufficient learning motivation. Together with the monotony in teaching methods and evaluation criteria, this old pattern directly hinders the improvement of teaching quality.

The course covers interdisciplinary theories such as botany, ecology and hydrology, and is featured by a highly abstract knowledge system that poses significant challenges for students.

Teachers must allocate considerable class hours in explaining basic theories, which objectively reduces the time and space available for practical instruction. The vocational scenarios of the major Soil Conservation and Desertification Control rely highly on practical skills, and require practitioners to work in complex environments (e.g., Gobi deserts, degraded grasslands, mining sites), necessitating the flexible transformation of theories into practical skills. The insufficient connection between abstract theories and complex practical scenarios ultimately leads to a severe disconnection between theories and practice in course teaching, making it difficult to effectively train students' ability to apply theories to solve practical problems.

3.2 Vague Course Orientation, and Hard to Achieve Students' Subjectivity

The position of the course in the professional talent training system is not clearly defined and only relatively closely associated with basic ecology courses, but lacks systematic connection with major trunk courses such as botany, engineering and hydrology. This situation prevents the course contents from fully aligning with the objectives of professional talent cultivation, which weakens the distinctive professional features of the course and prevents students from intuitively understanding the course, reducing their enthusiasm and interest in learning.

Traditional teaching contents emphasise the transmission of basic theories and established knowledge, but are severely lagged. On the one hand, the failure to timely integrate cutting-edge industry technologies (e.g., drone aerial surveying, GIS spatial analysis), and the insufficient alignment with the current industry standards (e.g., SL773-2018) have resulted in students' delayed mastery of the latest technical specifications and practical tools. On the other hand, the presentation of laws, regulations and technical standards related to soil conservation is monotonous and lacks concrete interpretation, making it difficult to stimulate students' proactive exploration. The combined effect of multiple factors leads to low classroom engagement and ineffective realisation of students' subjectivity.

3.3 Low Professional Identity and Poor Learning Effect of Students

Owing to traditional notions of 'neglecting agriculture' and 'disliking agriculture' coupled with cognitive bias stemming from urban-rural development disparities, the society generally holds stereotypes about agriculture and forestry majors, and perceives them as offering harsh working environments, remote locations, and low income. This perception directly leads to insufficient professional identity among students and dampens their enthusiasm for learning. Urban students are unwilling to enter the 'agricultural field', while rural students aspire to escape the 'agricultural field', resulting in lower admission scores for agricultural and forestry institutions and in student sources dominated by rural backgrounds within the province [11,12].

The monotonicity of student sources has led to multiple learning challenges. The high proportion of within-province local students and the limited number of out-of-province students restrict opportunities for interaction and integration with peers from diverse regions and with different thinking patterns and learning habits. Although rural students are diligent and earnest in learning, some of them are little exposed to new knowledge and ideas from the outside world and have relatively closed-minded perspectives. They are unwilling for self-expression and classroom participation, and lack both the initiative and capability for deep learning. These factors interact and ultimately result in suboptimal overall learning outcomes and difficulty in meeting the expected talent training requirements of the course.

4. Core Theoretical Basis: Guidelines Framework and Qualification System

4.1 Core Content System for Soil Conservation Plan Development

Based on SL773-2018 and relevant industry standards, the core content system for soil conservation plan development can be summarised into five modules: (1) Surveys into the project area: including natural factors (e.g., topography, soil type, meteorological conditions, vegetation coverage) and engineering factors (e.g., project construction scale, construction techniques, disturbance scope); (2) Soil erosion prediction: predicting soil loss volume, loss intensity and impact scope during construction and operation periods, as per the qualification methods specified in SL773-2018; (3) Division of prevention and control zones: dividing construction access roads, waste disposal zone, main project zone and other prevention zones, as per project disturbance characteristics and soil erosion sensitivity; (4) Layout of prevention and control measures: optimizing the allocation of engineering measures, vegetation measures and farming measures according to the soil erosion characteristics of different zones, and forming a comprehensive prevention and control system of 'block - intercept - store - drain - plant'; (5) Benefit analysis and monitoring plan: including ecological, economic and social benefit assessments, monitoring point placement, determination of monitoring indicators, and planning of monitoring frequency [13].

4.2 Technical System of Soil Loss Qualification Guidelines (SL773-2018)

As the unified technical standards for soil loss qualification in production and construction projects, SL773-2018 has an all-scenario qualification system covering water erosion and wind erosion. Its core technical framework consists of three parts: classification of erosion types, qualification flowchart, and key methods [2].

4.2.1 Three-level classification of soil loss types

The Guidelines adopt a three-level classification system to categorise soil erosion types (Table 1). The first-level classes are divided by soil erosion types under external erosive forces, including water and wind forces. The second-level classes are divided by the engineering disturbance form on the underlying surface, and include generally disturbed ground, engineering excavation surface, and engineering piles. The third-level classes are separated by disturbance degree, water flow from above, or other factors; under water forces, general disturbed ground is divided into the vegetation destruction type and the surface flip type; engineering excavation surface is divided into types with or without water from above. This classification system underlies the precise selection of qualification methods.

4.2.2 Standardised qualification flowchart

The soil loss qualification flowchart specified in SL773-2018 comprises five key steps. (1) Divide disturbance units, and based on consistency principles (e.g., disturbance type, soil type, meteorological conditions), divide the project area into several spatially contiguous disturbance units and classify them by the scale. (2) Select typical disturbance units: if the number of disturbance units is ≤20, select all units; otherwise, sample by type and scale (sampling ratio ≥10%). (3) Survey in field, measure or investigate geometric dimensions, vegetation cover, soil texture, and meteorological parameters of typical disturbance units on-site. (4) Divide qualification units: subdivide typical disturbance units by parameter consistency principles into basic units suitable for direct qualification. (5) Soil loss qualification: select corresponding equations based on erosion types, separately compute water erosion loss and wind erosion loss, and then add them together into the total erosion loss.

4.2.3 Core qualification methods

(1) Water erosion qualification

For general disturbed ground of the vegetation destruction type, the soil loss of each unit, M_{yz} (t), is computed using Eq. (1):

$$M_{yz} = RKL_yS_yBETA \quad (1)$$

where R is the rainfall erosivity factor (MJ·mm/(hm2·h)); K is the soil erodibility factor (t·hm2·h/(hm2·MJ·mm)); Ly is the slope length factor, Sy is the slope gradient factor, B is the vegetation cover factor, E is the engineering measure factor, T is the tillage measure factor (all dimensionless); A is the horizontal projected area of the qualification unit (hm2).

The soil loss of the general disturbed surface under the surface flip type in qualification units, M_{yd} (t), is calculated using Eqs. (2) and (3):

$$M_{yd} = RK_{yd}L_yS_yBETA \quad (2)$$

$$K_{yd}=\text{NK} \quad (3)$$

where K_{yd} is the soil erodibility factor after surface flip disturbance (t·hm2·h/(hm2·MJ·mm)); N is the increase coefficient of the soil erodibility factor after surface flip disturbance (dimensionless).

The soil loss of engineering excavation surface without water from above, M_{kw} (t), is calculated using Eq. (4):

$$M_{kw} = RG_{kw}L_{kw}S_{kw}A \quad (4)$$

where G_{kw} is the soil quality factor of engineering excavation surface without water from above (t·hm2·h/(hm2·MJ·mm)); L_{kw} is the slope length factor of engineering excavation surface without water from above (dimensionless); S_{kw} is the slope gradient factor of engineering excavation surface without water from above (dimensionless).

The soil loss of engineering piles without water from above, M_{dw} (t), is calculated according to

Eq. (5):

$$M_{dw} = XRG_{dw}L_{dw}S_{dw}A \quad (5)$$

where X is the morphological factor of engineering piles (dimensionless); G_{dw} is the soil quality factor of engineering piles without water from above (t·hm2·h/(hm2·MJ·mm)); L_{dw} is the slope length factor of engineering piles without water from above (dimensionless); S_{dw} is the slope gradient factor of engineering piles without water from above (dimensionless).

(2) Wind erosion qualification

The soil loss of general disturbed surface due to wind erosion (with wind times observations available), M_{f1} (t), is calculated using Eq. (6):

$$M_{f1} = IJ\sum(q_i t_i D_i) \quad (6)$$

where I is the roughness disturbance factor (dimensionless); J is the surface material compactness coefficient (dimensionless); q_i is the soil loss per unit width under the i-th wind effect (t(m·a)); t_i is the duration of the i-th observed wind effect (a); D_i is the maximum windward width of the qualification unit during the i-th observation (m).

The soil loss of engineering piles (with wind times observations available) due to wind erosion, M_{fd1} (t), is calculated using Eq. (7):

$$M_{fd1} = IHP\sum(q_i t_i D_i) \quad (7)$$

where H is the height factor of engineering piles under wind action (dimensionless); P is the stacking factor of engineering piles under wind action (dimensionless).

Table 1. Classification of Soil Erosion Types in Production and Construction Projects (SL773-2018)

Level 1 class	Level 2 class	Level 3 class	Core characteristics
Soil loss under water force	General disturbed ground	General disturbed ground of vegetation destruction type	Human activities cause damages to original forest and grass vegetation, and reduce or expose surface vegetation coverage, without disturbing surface soils and maintaining original overall topography on the disturbed ground surface.
		General disturbed ground of surface flip type	Human activities cause surface soil flip and significantly reduce original vegetation coverage, maintaining the original overall topography on the disturbed ground surface.
	Engineering excavated surface	Engineering excavated surface without water from above	The upper edge of the engineering excavated surface has reached or exceeded the watershed, or slope runoff interception measures such as intercepting and draining ditches are made at the top of the excavated surface, but the excavated surface is unaffected by water erosion from above.
		Engineering excavated surface with water from above	The upper edge of the engineering excavated surface has not reached the watershed, and there are no slope runoff interception measures (e.g., intercepting and draining ditches) at the top of the excavated surface, so the excavated surface is eroded by water from above.
	Engineering piles	Engineering piles without water from above	Piles exist on flat ground or slope, and are not eroded by water from above.
		Engineering piles with water from above	Piles exist on slope gullies or on flat ground but with a large platform at the top, and are subject to erosion from precipitation and water from above.
Soil loss under wind force	General disturbed ground	-	
	Engineering piles	-	

5. Teaching Reform Practice of Soil Conservation Plan Development

5.1 Reconstruction of Course Content System

The College of Desert Control Science and Engineering, Inner Mongolia Agricultural University, has modularly restructured the courses related to soil conservation plan development and soil loss qualification according to regional complex erosion characteristics and the SL773-2018 requirements (Table 2). The course contents are divided into four major modules: basic theory module, standard application module, regional characteristics module, and practical operation module. The basic theory module covers elective knowledge, such as principles of soil erosion, and hydrological fundamentals. The standard application module systematically explains the classification system, qualification flowchart and equation application of

SL773-2018. The regional characteristics module focuses on parameter adjustments for typical scenarios, such as grassland mining areas, desert edges, and hilly gully regions in Inner Mongolia (e.g., parameter coupling in wind-water complex erosion areas). The practical operation module includes virtual simulation qualification, on-site survey training, and plan development operations [14]. Additionally, the course contents incorporate elements related to the "dual carbon" goal, and supplement correlation analyses between soil carbon sequestration and soil erosion control.

Table 2. Modular Reconstruction Plan for Soil Conservation Plan Development and Soil Erosion Quantification Course

Module type	Core content	Teaching objective	Teaching method
Basic theory module	Soil erosion principles, hydrology, fundamentals of soil mechanics	To master theoretical support for qualification	Classroom teaching + case introduction
Standard application module	SL773-2018 classification system, qualification flowchart, equation application	To proficiently apply industry standards	Standard interpretation + exercise calculation
Regional characteristics module	Parameter adjustment for complex erosion areas, qualification examples in grassland mining areas, prevention measures at desert edges	To enhance regional adaptability	Special lectures + on-site teaching
Practical operation module	Virtual simulation qualification, on-site inspection, plan development	To strengthen practical application capability;	Virtual training + school-enterprise joint training

5.2 Teaching Method Innovations

5.2.1 Case-based and problem-oriented teaching

Typical production and construction projects in Inner Mongolia (e.g., Xilingol Grassland Mining Area, Inner Mongolia Section of Baotou-Maoming Expressway, Kubuqi Desert Photovoltaic Power Station) were selected as teaching cases. Students were guided into problem chain exploration centered on 'division of project disturbance units - acquisition of key parameters - soil loss qualification - optimisation of prevention/control measures' [15]. For example, in the soil erosion issue of waste dumps in grassland mining areas, students shall design progressive problems of 'rationality analysis of waste dump site selection - determination of pile slope ratio - soil loss qualification - design of blocking measures' to train their systematic thinking [16].

5.2.2 Integration of virtual simulation and field training

Construction of 'virtual-scenario-operation' trinity practical teaching system: A virtual simulation system for soil loss qualification in complex erosion areas was developed using technologies such as 3DMAX and GIS to simulate qualifications under different disturbance types. Students were organised to conduct field surveys at training bases such as Inner Mongolia Soil Conservation Supervision Bureau and grassland mining area remediation sites, where they learned how to operate devices (e.g., total stations and soil samplers) and measure parameters (e.g., terrain slope and soil texture). In collaboration with local soil conservation consulting firms, the students participated in the plan development and qualification of real projects to enhance their practical skills [17].

5.2.3 Interdisciplinary integrated teaching

Cross-disciplinary knowledge such as landscape ecology, 3S, and engineering mechanics was integrated, and specialised courses such as 'Application of remote sensing image interpretation in disturbance unit division' and 'Practice of GIS spatial analysis in parameter extraction' were established. Drone aerial survey was introduced to teach students how to use drones to obtain topographic data and vegetation coverage information in project areas, and to provide precise parameters for soil loss qualification.

5.2.4 Integration of ideological, political and industrial spirits

Typical soil conservation cases in Inner Mongolia, and the ideological and political elements of 'Three-North' Shelterbelt Project and the heroic deeds of desertification control were incorporated to foster students' ecological responsibility and industrial mission. Professional experts were invited to give special lectures and share frontier work experience and career development paths, which will enhance students' identity with this field.

5.3 Assessment and Evaluation System Improvement

A diversified assessment system incorporating 'processive evaluation + summative evaluation + professional certification' was established (Table 3). Processive evaluation accounts for 40%, and includes classroom case discussion, virtual simulation operation, and practical training reports. Summative evaluation accounts for 40%, and primarily focuses on comprehensive assignment of soil conservation plan development and erosion loss qualification in typical projects. Professional certification accounts for 20%, and encourages students to participate in the vocational qualification exam for soil conservation monitoring technicians, with exam results included in the assessment [18]. Additionally, professional experts were invited to participate in the assessment review, with focus on measurement accuracy, plan feasibility, and regional adaptability.

Table 3. Diversified Course Assessment and Evaluation System

Assessment type	Assessment content	Weight	Evaluation party
Processive evaluation	Classroom discussion, virtual simulation operation, practical training report	40%	On-campus teachers
Summative evaluation	Water conservation plan development + comprehensive operation on erosion qualification	40%	On-campus teachers + professional experts
Professional certification.	Vocational qualification exam results for water conservation monitoring workers	20%	Vocational skill appraisal institution

Table 4. SL773-2018 Parameter Adjustment Recommendations for Typical Regions in Inner Mongolia

Application scenario	Dominant erosion type	Core adjusted parameters	Adjustment method
Grassland mining area	Water + wind complex erosion	Soil rock quality factor, vegetation coverage factor	On-site sampling to determine soil-rock ratio; drones to monitor vegetation coverage
Desert edges	Dominated by wind erosion	Starting wind speed, roughness disturbance factor	Wind speed data from local meteorological stations; surface gravel coverage from field surveys
Hilly gully areas	Dominated by water erosion	Rainfall erosivity factor, slope length factor	R calibrated as per multi-year county-level rainfall data; terrain slope length and gradient measured on site
Mining expansion project. (tailing pond)	Water + gravity erosion	Soil rock quality factor, slope factor	Soil rock quality factor adjusted as per soil-rock ratio in the piles; slope factor modified according to the designed slope ratio

6. Practical Application of Soil Erosion Qualification Guidelines in Inner Mongolia

6.1 Typical Application Scenarios and Parameter Adjustment

The characteristics of wind-water complex erosion in Inner Mongolia necessitate targeted parameter adjustments for the application of SL773-2018 guidelines (Table 4). In grassland mining areas, engineering piles are mostly soil-rock mixtures, and field sampling is needed to correct soil and rock quality factors. In desert edges dominated by wind erosion, parameters such as wind speed and surface roughness shall be acquired specially, and the wind erosion qualification equation is adopted. In hilly gully areas with intense water erosion, localised calibration of rainfall erosivity factor R must be strengthened (based on long-term observations from local meteorological stations). In mining expansion projects, engineering piles such as tailing ponds require that soil and rock quality factors and slope factors shall be adjusted as per the pile type and slope ratio.

6.2 Application Effectiveness and Case Analysis

In the Zhuanshanzi gold mine 180,000 t/a gold ore mining expansion project under Chifeng Jilong Mining Co., Ltd., the SL773-2018 guidelines were applied to qualify the soil loss during the construction period. The project is located in Aohan Banner, Chifeng, Inner Mongolia, and characterised by loess hills with a geomorphy typical of the North China rocky mountainous region. The primary soil erosion type is water erosion accompanied by light wind erosion. The water erosion modulus of original terrains is 3,000 t/(km^2·a), the wind erosion modulus is 800 t/(km^2·a), and the allowable soil loss is 500 t/(km^2·a).

The project disturbance units were divided into four types: an ore processing plant zone, a tailing pond zone, a tailing transport pipeline zone, and an ore transport road zone. Six typical disturbance units were selected for on-site surveys. The measured slope of the tailing pondzone is 28°, vegetation coverage rate is 12%, and the soil texture is sandy loam. The ore processing plant zone has a slope length of 85 m, a slope gradient of 10°, and vegetation coverage of 15%. The tailing transport pipeline zone has a disturbance width of 3 m and vegetation coverage of 8%. Calculations with the equations in the guidelines show the water erosion volume is 186.4 t/(km^2·a), the wind erosion volume is 98.7 t/(km^2·a), and the total soil loss is 285.1 t/(km^2·a), with an increase of 186.4 t/(km^2·a) from the natural state.

Based on the calculations, targeted control measures were optimised and allocated. Drainage ditches were set along the retaining wall toes and road edges in the ore processing plant zone, while grouted stone revetments and square skeleton revetments were built at dug-and-fill slopes, and trees and grasses were planted in open areas. In the tailing pond zone, square skeleton revetments and greening were applied to the slopes near the filter press workshop; dam shoulder and dam surface drainage ditches were constructed on the tailing dams; an energy dissipation pool was installed at the outlet of the flood discharge culvert. A vegetation restoration measure was supplemented in the construction-disturbed areas of the tailing pipeline zone and the ore transportation road zone. Monitoring showed soil loss decreased to 45.3 t/(km^2·a) after implementation, achieving a prevention and control effect of 84.1%. The prevention and control targets in the design level year were achieved, including a soil erosion control rate of 95%, a soil loss control rate of 0.9, and a muck protection rate of 97%.

7. Conclusions

The teaching reforms of the Soil Conservation Plan Development course closely adhere to the standardised requirements of the SL773-2018 guidelines and the characteristics of complex erosion areas in Inner Mongolia. The comprehensive approach of 'modular content reconstruction to strengthen knowledge connection; diversified teaching innovations to activate practical skills; all-round assessment improvements to ensure training quality; regionalised parameter adjustments to enhance application effectiveness' effectively addresses the three major pain points in traditional teaching, and achieves a closed loop of 'standard implementation - teaching empowerment - practice efficiency enhancement'. After the reforms, students' abilities of soil conservation plan development, qualification accuracy controlling, and on-site practical operations were significantly improved. The course has cultivated a group of versatile talents for the ecologically fragile region of North China who 'understand standards, excel in qualification, excel in practice, and adapt to regional needs', and provides reproducible experience for the construction of related disciplines in similar universities and colleges.

Currently, the reforms still face challenges, such as the imperfect complex erosion coupling qualification model, lack of basic data in remote areas, and insufficient integration with new technologies including AI. In the future, the course teaching needs to further strengthen interdisciplinary collaboration and deepen the application of 3S and AI in parameter extraction and model simulation. The local parameter database and virtual simulation teaching resources in Inner Mongolia shall be continuously improved so as to combat the difficulty in value selection of region-specific parameters. University-enterprise collaboration shall be enhanced to allow students to deeply engage in the entire process of real projects, so as to achieve thorough integration of 'teaching and practice'. Given the 'dual-carbon' goal and the needs of ecological civilisation, future efforts will further optimise the reform paths, advance the course from 'standard application' to 'standard innovation', and upgrade it from 'regional adaptation' to 'regional leadership'. This effort will provide stronger talent support and technical guarantee for soil erosion control in Inner Mongolia and other ecologically fragile areas of North China, and contribute to consolidating the North China ecological security barrier and the high-quality ecological civilisation through higher education.

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