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BIOENGINEERING: THE USE OF PLANT BIOMASS TO STABILIZE AND RECLAIM HIGHLY DISTURBED SITES.

The bioengineering concept of reclamation developed in Europe is now becoming well established internationally with successful projects in Japan, Korea, New Zealand, Rhodesia, South Africa, Venezuela and the North American Continent. It is proposed as an alternative to conventional reclamation methods, particularily where conventional methods are producing less than desirable results.

I. Doubtless the plant cover is the most important protection layer for the soil surface and for the upper soil layers. It is, therefore, only logical to use live plants when a restoration of disturbed conditions in the landscape becomes necessary.

A program maintaining this idea was developed in the 1930's and originally called LIVE CONSTRUCTION. Today we are in a position to offer a series of so-called BIOENGINEERING BUILDING SYSTEMS, which have all been tested and proved successful under the most diverse conditions.

A bioengineering building system is the application of live plants or plant material either exclusively or in combination with dead material.

Basically these systems serve the stabilization of certain terrain sections and the improvement of ecological conditions in utilizing natural materials available at the building site. We thereby are provided with a means to preserve and protect something already established as well as repair damage by establishing new eco-systems in those areas devoid of vegetation.

In order to be able to apply bioengineering methods it is essential to know the building material - i.e. the suitable plants. Their propagation (especially vegetation propagation), their requirements of the locality, their bio-technical qualifications (i.e. resistance to burying, to erosion, their root development and root hardiness, the soil penetration, their regeneration ability after ...

damage etc.) must be known as well as their position in the natural plant succession - the pioneer phase, medium phase and final phase or climax community. Beside all that a sound knowledge of technical engineering is necessary.

II. WHERE LIES THE DIFFERENCE BETWEEN A BIOENGINEER AND CONVENTIONAL RECLAMATION WORK

The conventional approach to reclamation work usually utilizes specialist disciplines such as; forestry, agriculture, soil mechanics, biology, engineering, architecture etc., whereas the bioengineer receives a more comprehensive and more diversified training. He looks at a problem in reclamation work from the forester's, the agriculturist's, the biologist's, the landscape architect's, the soil specialist's, and the engineer's point of view all at once and considers all factors involved in reclamation work, such as; soil conditions, climatic conditions, characteristics and suitability of individual plants, technical, engineering and aesthetic aspects, specific problems of a certain locality, like altitude, slopes, water conditions, plant cover etc.
Professor Schiechtl, for example, is a civil engineer, a botanist and a landscape architect. He has been and is now being consulted by 17 different countries, including Libya, where at the moment the largest revegetation program in the world has been carried out for the last five years.
Reclamation personnel all over the world often try to "invent" systems already well known and established in bioengineering. To most problems the solutions have already been found and all one should do is to try to improve these established systems instead of re-inventing.
Bioengineering systems have long been standardized in German and Austrian construction codes and we strongly recommend a translation of these construction standards. Most common mistakes seen through past experience in reclamation work are:

1. Seeds and plants chosen were not suitable for their specific requirements; they had rather been picked according to availability, familiarity and costs. In many cases not enough plant varieties were used.
   Another point very rarely considered was the root production and the tensile root strength.
2. Plantings were carried out in blocks or rows instead of mixed random planting, which would have promoted a diversified root development and the development of a very resistant vegetation cover, which survives even if diseases, insects or fungi destroy some of the varieties. Nothing is worse than monoculture and block planting where suddenly a whole group of plants can vanish, apart from that it does not add to the aesthetic value of the area.
   An example of what may happen was seen in Kentucky where whole blocks of container planted pines were blown over by winds after approximately <u>twenty</u> years of planting. See in comparison Korean steep highway banks which were stabilized through the application of concrete gratings seeded with grass and random planting with a great variety of shrubs and trees. After twelve years a healthy, well-balanced vegetation cover was established.
   Another example of how planting should not be done is a slide area revegetated with pines, monoculture, straight rows in vertical direction instead of mixed planting and random spacing. This planting could be completely destroyed at any one time.

III. MOST IMPORTANT BIOENGINEERING BUILDING SYSTEMS

We differentiate between

1. COMBINED BUILDING SYSTEMS
   where hard construction (used in conventional technical engineering or

reclamation work) are combined with live building materials. Their purpose is the stabilization and drainage of slope sections and the securing of erosion gullies to prevent further erosion). In Hydro construction, they serve as shore protection (Bank and SLOPE STABILIZATION and PROTECTION SYSTEMS along WATERWAYS).

The most important of these Combined Systems are KRAINERWALLS, made from timber or prefabricated concrete parts that are vegetated with live branches of some woody varieties such as; VEGETATED GABIONS, LIVE SLOPE GRATINGS, VEGETATED PALISADE AND POLE CONSTRUCTION, BRANCH LAYERING OF GULLIES, LIVE FASCINE DRAINS, LIVE STAKE DRAINS, LIVE KUENETTE (open water channel), and LIVE DRAIN WEDGE.

In Hydro contruction, mainly LIVE BRUSHES, REED PLANTINGS with root stocks, rhizomes and sprigs, WATTLES, FASCINES, SPREITLAGEN, ROCKFILLS WITH BRANCH LAYERING, BUSCHBAUTRAVERSE (LIVE SILTATION CONSTRUCTION), GITTERBUSCHBAUWERK (an arrangement of pegs or pilots and branches or trees), and BRANCH PACKINGS are used.

2. STABILIZING CONSTRUCTIONS

Their purpose is a deep-reaching soil stabilization and compaction and the consolidation of loose material. The most effective and today most commonly used stabilization constructions are the LAYER CONSTRUCTIONS (HEDGE LAYER, BRUSHLAYER AND HEDGE-BRUSH LAYER CONSTRUCTION), the various methods of PLANTING OF CUTTINGS, WATTLE FENCES and SLOPE FASCINES.

3. SURFACE PROTECTION CONSTRUCTIONS

They serve the protection of the soil surface from erosion and damage through tensile and compressive forces caused by heavy rain, hail and wind. The most commonly used ones are TURF AND LAWN SEEDINGS, and SPREITLAGEN CONSTRUCTION, which protects the soil surface through the placement of a layer of live branc as well as all SODDING SYSTEMS.

4. SUPPLEMENTARY BUILDING SYSTEMS

Their purpose is the improvement and stabilization of the established initial vegetation and the promotion of its further natural development into the climax vegetation. The most important methods are SEEDING OF WOODY PLANTS and the various PLANTING and AFFORESTATION SYSTEMS.

IV. APPLICATION FIELDS AND EFFECTS OF BIOENGINEERING METHODS

Bioengineering building systems can be applied both in hydro construction and earth work. Their immediate application has in fact, prevented permanent damage on a huge scale that would have resulted from most construction projects. The use of bioengineering systems is justified if one of the functions that are listed in the chart below has to be fulfilled. Their application is absolutely necessary if these requirements can not be sufficiently fulfilled by hard construction.

Requirements for the effect of bioengineering building systems

Earth Work	Hydro Construction

Technical Effects

Protection against wind-, rain-, and frost erosion

Protection of the soil surface against wind-, rain-, and frost erosion | and erosion by flowing water

Protection against rock fall

Protection of the soil surface against damage from heavy rain and hail | and drifting ice

Elimination or control of damaging mechanical forces, thereby prevention of e.g. minor slides

surficial or deep-reaching soil stabilization and compaction thereby e.g. raising of the possible slope inclination angle

Earth Work	Hydro Construction
Protection against blinding and thereby optical channelling effect	reduction of current in the shore area
traffic	reducement of the waves
drainage	water purification (cleansing)

increase of roughness of soil and thereby prevention of avalanches

promoting the snow deposit, incl. avalanches and moving material (only possible with woody plants)

Wind protection

Economical Effects

- Reduction of construction costs compared to hard construction (conventional engineering construction)
- Reduction of costs for maintenance and for repair and restoration
- Providing usable green areas and forest communities with vegetation on previously barren land.

Earth Work	Hydro Construction

Ecological Effects

Improvement of water conditions through higher interception of the water-retention capacity of the soil and of water consumption through transpiration

Drainage of Soil

Wind protection

Immission protection

loosening and stabilization of the soil through penetrating plant roots

Stabilizing the temperature conditions in the soil and in the air layers near the soil

Shading

Improvement of nutrient content of soil through decaying plant parts, through symbiosis and Allelo-parasitism; thereby inducing biological cycles, creation of an animated top (surface) soil layer, activation of the soil fauna and flora and thus increase of soil fertility in previously raw mineral soils.

Control of snow deposit

improvement of spawning places

Increase of production in re-shaped areas behind wind protection systems

Landscape - Architectural
(Aesthetic) Effects

- Reduction of construction costs compared to hard construction (conventional engineering construction).
- Reduction of costs for maintenance and for repair and restoration.
- Providing usable green areas and forest communities with vegetation on previously barren land.

Bioengineering systems have numerous advantages compared to conservative engineering systems applied in reclamation work (also called Hard Constructions). Certain technical functions such as; erosion control, protection of the soil surface against heavy rain and hail, deep-reaching soil stabilization and consolidation, reduction of current and waves etc., can not be fulfilled as effectively by any of the Hard Constructions as with bioengineering methods. This goes to an even greater extent for ecological functions, and for aesthetic and economic effects.

V. MAINTENANCE

From past experience we can prove that the preservation and maintenance of bioengineering systems is in comparison to hard constructions, simple and economical. If the appropriate plant varieties and bioengineering methods have been chosen, little maintenance is necessary. Through the natural plant succession the established initial vegetation should develop into the climax community by itself.
At extreme unfavourable localities this development can be promoted and accelerated through the application of SUPPLEMENTARY BUILDING SYSTEMS with some fertilization, mowing, and pruning of woody plants etc.

VI. VARIOUS EXAMPLES OF BIOENGINEERING SYSTEMS AND THEIR PRACTICAL APPLICATION.

Pictures and diagrams shown.
The examples presented show approximately 1% of the total amount of bioengineeri systems known and applied today. We hope that it will give you some impression of what we are trying to explain and that you were able to get the main idea of what bioengineering systems are all about.

We would also like to point out quite clearly that we are not fully qualified bioengineers though we have been using some basic systems. We have been convinced of their great importance in the field of reclamation work and their immense value to anyone concerned about his/her environment.

VII. WHERE CAN WE LEARN THE MOST ABOUT CERTAIN SPECIFIC PROBLEMS IN RECLAMATION WORK?

1. Steep slopes - Austria, Switzerland, Italy, Korea, Japan.
2. Toxic material - Rhodesia, S.Africa, Germany, Austria, France.
3. Sand - Holland, N.Germany, France, US Pacific and US Atlantic coast, State of Washington, Tunisia, S.Africa, Israel, S.W.Africa, Southern France.
4. Salt - Holland, N.Germany, Tunisia, S.Africa, Japan, Israel.
5. High Altitude and Arctic Climates - European Alps, Norway, Sweden, Alaska.
6. Wind problems - S.Africa, Tunisia, Israel, Southern France, Iran.
7. Water - European Alps, Holland, N.Germany, and the leading water institutes in Germany.
8. Ski runs and avalanch control - Austrian, Swiss and German Alps.

The most important reclamation projects that we have seen or are aware of are in our opinion Mr. Perry Plummer's work in Utah, the late Mr. Kraeble's work in California, Mr. Hill's work in Rhodesian copper mines, and in Europe various projects by Professor Schiechtl and others.
Other projects of interest are the Brown coal mines in Germany and the largest current reclamation project of its' kind in the world now in its' fifth year in Libya under the auspicious Khadify regime.
The most extensive records available on a reclamation project are in Grenoble, S.E. France, where a whole district was declared a disaster area approximately 250 years ago and where the mountains have been gradually revegetated during this period.

We are grateful to the organizers of this conference for providing us with the opportunity of presenting this material.
It is our belief, based on our own experience, that the potential for the bioengineering concept of reclamation has not yet been realized here, and we firmly believe that many applications exist where better results could be achieved, both from the stand point of economics and long term solutions.

Thank you

PROCEEDINGS

OF

THE SECOND ANNUAL GENERAL MEETING

OF THE

CANADIAN LAND RECLAMATION ASSOCIATION

August 17, 18, 19 & 20 — 1977 Edmonton, Alberta

(Sponsored by the Faculty of Extension, University of Alberta)

P R O G R A M

Canadian Land Reclamation Association

Second Annual General Meeting

August 17, 18, 19, 20, 1977

Edmonton, Alberta

Wednesday, August 17 (Optional Field Trips)

Field Trip No. 1 (Athabasca Tar Sands)

Leader: Philip Lulman (Syncrude Canada Ltd.)

Fee: $100.00 (covers bus and air transportation, lunch, and field trip information pamphlets)

Schedule: 7:30 am.- delegates board bus at Parking Lot T, located immediately south of the Lister Hall Student Residence complex. Air transportation from Edmonton Industrial Airport to Fort McMurray and return. Guided bus tour of surface mining and reclamation operations on Syncrude Canada Ltd. and Great Canadian Oil Sands Ltd. leases.
6:30 p.m.- delegates arrive back at Parking Lot T, University of Alberta campus.

Field Trip No. 2 (Aspen Parkland; Forestburg Coal Mine Reclamation)

Leader: George Robbins (Luscar Ltd.)

Fee: $25.00 (covers bus transportation, lunch, and field trip information pamphlets)

Schedule: 8:00 a.m. - delegates board bus at Parking Lot T, located immediately south of the Lister Hall student residence complex. Guided bus tour southeast of Edmonton, stopping at various points of interest (oil spill reclamation field plots; Black Nugget Park [abandoned minesite]; trench plots on Dodds-Roundhill Coal Field; solonetzic soil deep ploughing site) on the way to the Luscar Ltd. Coal Mine at Forestburg.
6:30 p.m. - delegates arrive back at Parking Lot T, University of Alberta campus.

Thursday, August 18

Events:	Opening of Formal Meeting; Presentation of Papers
Location:	Multi-Media Room, located on second floor of Education Building, University of Alberta.
8:00 a.m.	Authors of papers being presented on August 18 meet with paper presentation chairmen and audio-visual co-ordinator (Douglas Patching)
9:00 a.m.	Meeting Opened by Dr. Jack Winch (President of the C.L.R.A.; Head of the Department of Crop Science, University of Guelph). Comments by Dr. Winch.
9:15 a.m.	Welcome to delegates on behalf of the Government of Alberta by the Hon. Mr. Dallas Schmidt, (Associate Minister Responsible for Lands, Alberta Department of Energy and Natural Resources)
9:25 a.m.	Commencement of Paper Presentations. Morning session chaired by Mr. Henry Thiessen (Chairman of the Land Surface Conservation and Reclamation Council and Assistant Deputy Minister, Alberta Department of Environment).
9:30 a.m.	Paper 1. Combined Overburden Revegetation and Wastewater Disposal in the Southern Alberta Foothills by H.F. Thimm, G.J. Clark and G. Baker (presented by Harald Thimm of Chemex Reclamation and Sump Disposal Services Ltd., Calgary, Alberta).
10:00 a.m.	Paper 2. Brine Spillage in the Oil Industry; The Natural Recovery of an Area Affected by a Salt Water Spill near Swan Hills, Alberta by M.J. Rowell and J.M. Crepin (presented by Michael Rowell of Norwest Soils Research Ltd., Edmonton, Alberta)
10:30 a.m.	Coffee Recess
11:00 a.m.	Paper 3. The Interaction of Groundwater and Surface Materials in Mine Reclamation by Philip L. Hall of Groundwater Consultants Group Ltd., Edmonton, Alberta.
11:30 a.m.	Paper 4. Subsurface Water Chemistry in Mined Land Reclamation; Key to Development of a Productive Post-Mining Landscape by S.R. Moran and J.A. Cherry (presented by Stephen Moran of the Research Council of Alberta, Edmonton, Alberta).
12:00 noon	Lunch Recess

1:25 p.m. Continuation of Paper Presentations. Afternoon session chaired by Mr. Philip Lulman (member of C.L.R.A. executive; reclamation research ecologist with Syncrude Canada Ltd.).

1:30 p.m. Paper 5. Coal Mine Spoils and Their Revegetation Patterns in Central Alberta by A.E.A. Schumacher, R. Hermesh and A.L. Bedwany (presented by Alex Schumacher of Montreal Engineering Company Ltd., Calgary, Alberta).

2:00 p.m. Paper 6. Surface Reclamation Situations and Practices on Coal Exploration and Surface Mine Sites at Sparwood, B.C. by R.J. Berdusco and A.W. Milligan (presented by Roger Berdusco of Kaiser Resources Ltd., Sparwood, B.C.).

2:30 p.m. Paper 7. Agronomic Properties and Reclamation Possibilities for Surface Materials on Syncrude Lease #17 by H.M. Etter and G.L. Lesko (presented by Harold Etter of Thurber Consultants Ltd., Victoria, B.C.).

3:00 p.m. Paper 8. The Use of Peat, Fertilizers and Mine Overburden to Stabilize Steep Tailings Sand Slopes by Michael J. Rowell of Norwest Soils Research Ltd., Edmonton, Alberta.

3:30 p.m. Coffee Recess

4:00 p.m. Paper 9. Oil Sands Tailings; Integrated Planning to Provide Long-Term Stabilization by David W. Devenny of E.B.A. Engineering Consultants Ltd., Edmonton, Alberta.

4:30 p.m. Paper 10. Bioengineering. The Use of Plant Biomass to Stabilize and Reclaim Highly Disturbed Sites by H. Schiechtel and K. (Nick) Horstmann (presented by Margit Kuttler).

5:00 p.m. End of August 18 Sessions.

Friday, August 19

Events:	Presentation of Papers; C.L.R.A. Annual General Business Meeting; C.L.R.A. Annual Dinner.
Locations:	Paper presentations and C.L.R.A. Annual General Business Meeting in Multi-Media Room, located on second floor of Education Building, University of Alberta. - Annual Dinner held in Banquet Room located on second floor of Lister Hall.
8:00 a.m.	Authors of Papers being presented on August 19 meet with paper presentation chairmen and audio-visual co-ordinator (Douglas Patching).
8:30 a.m.	Showing of Film Rye on the Rocks. This film depicts reclamation situations at Copper Cliff, Ontario and is being shown for the purpose of introducing delegates to the site of the 1978 C.L.R.A. meeting (Sudbury, Ontario).
8:55 a.m.	Continuation of Paper Presentations. Morning session chaired by Dr. J.V. Thirgood (Vice-President of C.L.R.A.; member of Forestry Faculty, University of British Columbia).
9:00 a.m.	Paper 11. Reclamation of Coal Refuse Material on an Abandoned Mine Site at Staunton, Illinois by M.L. Wilkey and S.D. Zellmer (presented by Michael Wilkey of the Argonne National Laboratory, Argonne, Illinois).
9:30 a.m.	Paper 12. A Case Study of Materials and Techniques Used in the Rehabilitation of a Pit and a Quarry in Southern Ontario by Sherry E. Yundt of the Ontario Ministry of Natural Resources, Toronto, Ontario).
10:00 a.m.	Coffee Recess.
10:30 a.m.	Paper 13. Amelioration and Revegetation of Smelter-Contaminated Soils in the Coeur D'Alene Mining District of Northern Idaho by D.B. Carter, H. Loewenstein and F.H. Pitkin (presented by Daniel Carter of Technicolor Graphic Services Inc., Sioux Falls, South Dakota).
11:00 a.m.	Paper 14. The Influence of Uranium Mine Tailings on Tree Growth at Elliot Lake, Ontario by David R. Murray of the Elliot Lake Laboratory, Elliot Lake, Ontario.

11:30 a.m. Paper 15. Weathering Coal Mine Waste. Assessing Potential Side Effects at Luscar, Alberta by D.W. Devenny and D.E. Ryder (presented by David Devenny of E.B.A. Engineering Consultants Ltd., Edmonton, Alberta).

12:00 noon Lunch Recess.

1:25 p.m. Continuation of Paper Presentations. Afternoon session chaired by Dr. John Railton, (Manager, Environmental Planning, Calgary Power Ltd., Calgary, Alberta).

1:30 p.m. Paper 16. The Distribution of Nutrients and Organic Matter in Native Mountain Grasslands and Reclaimed Coalmined Areas in Southeastern B.C. by Paul F. Ziemkiewicz of the Faculty of Forestry, University of B.C., Vancouver, British Columbia.

2:00 p.m. Paper 17. Systems Inventory of Surficial Disturbance, Peace River Coal Block, B.C. by D.M. (Murray) Galbraith of the British Columbia Ministry of Mines and Petroleum Resources, Victoria, British Columbia.

2:30 p.m. Paper 18. The Selection and Utilization of Native Grasses for Reclamation in the Rocky Mountains of Alberta by D. Walker, R.S. Sadasivaiah and J. Weijer (presented by David Walker of the Department of Genetics, University of Alberta, Edmonton, Alberta).

3:00 p.m. Coffee Recess; Distribution of Proceedings.

3:30 p.m. Commencement of 1977 General Business Meeting of the Canadian Land Reclamation Association. Meeting chaired by Dr. J.V. Winch, C.L.R.A. President.

7:30 p.m. Commencement of C.L.R.A. Annual Dinner in Banquet Room, second floor of Lister Hall.

Guest Speaker: William T. Plass, Principal Plant Ecologist, U.S.D.A. Forest Service, Northeastern Forest Experiment Station, Princeton, West Virginia.

Topic of Speech: Challenges in Co-operative Reclamation Research.

Note: Following the Annual Dinner and Mr. Plass's speech, delegates may retire to the adjacent Gold Room. A bartender will be on service until midnight.