USE OF PULP AND PAPER BYPRODUCTS IN SOIL STABILIZATION

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Industrial Materials Use in Sustainable Pavement Systems: State of the Practice

Indianapolis, IN November 28-29, 2012

Presentation Coverage

- Introduction to NCASI
- Background on the U.S. pulp and paper industry
- Review of the generation, characteristics, and management of two major byproduct solids
- Discussion of research and practice related to soil stabilization

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NCASI
National Council for Air and Stream Improvement

- Non-profit technical organization focusing on environmental issues of the forest products industry
- Technical personnel includes ≈ 70 scientists and engineers
- Member companies represent >90% of the pulp and paper and a large fraction of wood products produced in U.S.
- NCASI activities include research and information gathering, technical assistance and mill support, and education and training
- For its members NCASI produces technical reports, newsletters, regulatory alerts, handbooks, meeting proceedings, webinars, and podcasts

…environmental research for the forest products industry since 1943

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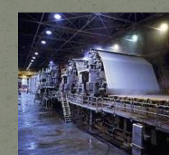
U.S. Pulp and Paper Industry

- 360 pulp & paper mills operating at present
- National annual capacity in 2009: 94 million tons of paper, paperboard, and market pulp



- Mills are located in 40 states. Top 10 states in 2000:
  GA AL LA SC VA WA OR WI MI ME
- Variety of mill capacities, manufacturing processes, raw materials, fuels, and end products

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Byproduct Generation

- Annual generation of byproduct solids and solid wastes by the U.S. pulp and paper industry:
  ≈ 15 million dry tons
- Including two major materials
  - Wastewater treatment plant (WWTP) residuals ("paper mill sludge")
  - Power boiler ash
- This presentation will review these two materials relative to material properties and use in soil stabilization

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A Couple of Points

- An industrial byproduct might be beneficially used
  - As is (no major processing)
  - After major processing (e.g., boiler ash carbon removal)
  - After blending with other byproducts or virgin materials
- Soil stabilization considered here in a broad fashion
  - On the roadside
  - In the road course

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Beneficial Uses of Paper Industry Byproducts

- Significant outlets are agriculture including land reclamation (both material types), onsite combustion for energy recovery (WWTP residuals), and earthen construction (boiler ash)

- To date, transportation-related uses have mostly been confined to
  - Research and demonstration projects in the U.S.
  - Established programs involving a limited number of U.S. mills
  - R&D and experience outside the U.S.
  - R&D and experience involving secondary roads

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WWTP Residuals

- ≈ 5.5 million dry tons annually in U.S.
- Types
  - Primary (including deinking residuals) – Solids from settling of raw wastewater
  - Secondary (waste activated sludge) – Solids from settling of biologically treated wastewater
  - Combined primary and secondary
  - Dredged
- Mechanical dewatering is the norm, with a solids content typically 30-40%, range 20-60%*
- Very small number of mills dry residuals (70-95% solids*)

** Solids content expressed on total-weight basis*

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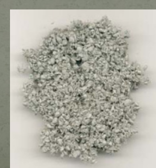
Primary WWTP Residuals

- Primary WWTP residuals consist mainly of
  - Wood fiber and wood fines
  - Mineral or inorganic matter (e.g., kaolin clay, $CaCO_3$, TiO_2)
- "Ash" (mineral) content of primary WWTP residuals ranges from <10% to >70% (dry wt. basis)
- At typical solids contents, residuals are characterized by high compressibility and low shear strength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WWTP Residuals at the Roadside

- Soil stabilization / Erosion control
  - Incorporated into the soil
  - Surface application (mulch including hydromulch)
- Documentation of erosion control is somewhat limited but growing, mostly agricultural and mine reclamation settings
- Anecdotal evidence from use in caps for landfill closure
- Research in Iowa and Virginia demonstrated that composts made with mill WWTP residuals were effective in controlling erosion

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WWTP Residuals in Road Stabilization

- Starting in 1977, loose-sand roads in the Chequamegon National Forest, WI, were stabilized with residuals
- Incorporation was done at a rate of about 5% dry-wt. to a depth of about 6 inches
- The mixture formed a stable surface, substantially reducing erosion
- Rutting could occur in low-lying areas with poor drainage and during heavy rain
- Residuals addition was reserved for lower-volume roads in areas deficient of readily available aggregate
- Cost-per-mile was ≤15% than that for using aggregate

Ash from WWTP Residuals

- Thermal treatment of WWTP residuals can produce material ("PSA") high in lime and/or metakaolin, depending on residuals composition and combustion conditions
- Field work in Spain on a roadway turnaround found PSA could function as the sole soil binder or as a cement additive
- Nippon Paper in Japan has reported use of PSA for soil stabilization both on the roadside (mixed with municipal biosolids) and under/on the road
- PSA ("TopCrete") is employed commercially for road soil stabilization in the Netherlands by contractor TerraStab

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Ash from WWTP Residuals

- An engineering company in Georgia is pursuing the commercialization of PSA in the U.S.
- US mills most often burn WWTP residuals along with wood or coal rather than residuals alone
- There have been instances of residuals going to U.S. cement plants as raw material

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Power Boiler Ash

- ≈ 4 million dry tons annually in U.S.
- Types (based on fuel)
  - Wood including bark
  - Coal
  - Wood and coal
  - Wood, coal, or both with miscellaneous solid fuels
- Wood ash
  - Often high in unburned carbon
  - Often high in calcium
  - Usually cementitious or pozzolanic
- With concerns about global warming, the generation of biomass ash and multi-fuel (coal-biomass) ash is growing

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Wood Ash in Road Soil Stabilization

Canada

- Laboratory research at Univ. of Guelph demonstrated that a wood fly ash (LOI = 21%, Ca = 250 mg/kg) could improve the strength and stiffness of soil
- The lab work was confirmed in field research by treating a landfill haul road having clayey soil, which resulted in reduced rutting
- Subsequently, the pulp mill involved in the research began to routinely treat forest haul roads with the fly ash
- The treated roads have an increased allowable load during the winter

Wood Ash in Road Soil Stabilization

Austria

- Laboratory and field work with wood ashes (bottom and fly) from stoker (SB) and fluidized-bed (FB) boilers
- Field demonstration with lime as control (Section 1), FB fly ash (Section 2), and SB bottom-fly ash mixture (Section 3)
- Initial conclusion is that, based on technical performance, wood ash can be used in road soil stabilization, and at a lower cost than lime
- The stabilization properties of wood ash depend on particle size (smaller the better) and CaO content (higher the better)

Wood Ash in Road Soil Stabilization

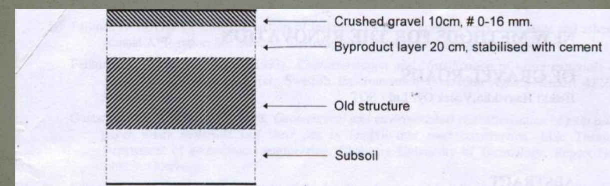
Finland

- Fly ashes (wood and wood-peat) and ash-WWTP residuals mixtures have been used in demonstration projects to renovate unpaved and low-volume paved roads
- A mixture of WWTP residuals and fly ash* yields a material with good frost insulation, bearing capacity and workability
- The residuals-ash mixture was also a fill material in the construction of shoulders on a narrow gravel road
- Sampling of groundwater during several years for various inorganic parameters indicated "no risk to the environment."

** Binder (cement, lime or gypsum) at 1% to 2% may also be added.*

Wood Ash in Soil Stabilization & Road Construction

- This work has lead to some routine use of wood ash and residuals-ash mixtures in road construction
- Similar activity is occurring in Sweden, and Finland is assisting Russia to develop demonstration project



Questions and Comments

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